Riverside County
Perris, California

SPECIFICATION NO. 1375S
MORENO VALLEY REGIONAL WATER RECLAMATION FACILITY
TERTIARY EFFLUENT EQUALIZATION PROJECT

Work Order # 414541

A PUBLIC WORKS PROJECT

VOLUME 2 OF 3

Contents:
Specifications | Notice Inviting Bids | Bidding Requirements | Bid Forms | Contract Forms |
Conditions of Contract

Paul D. Jones, II, P.E. - General Manager

Safety is of paramount and overriding importance to Eastern Municipal Water District

Visit our website at www.emwd.org to view currently advertised projects
Navigate to Construction ➔ Construction Bid Opportunities
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VOLUME 3

CONSTRUCTION DRAWINGS
SECTION 01110

SUMMARY OF WORK

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Identification and summary description of the Project, the Work, location, District-furnished products, activities by others, coordination, and early occupancy by District.

1.02 THE WORK

A. The Work consists of construction of Moreno Valley RWRF Tertiary Effluent Equalization Pond, including modifications to the existing Storm Water Pond to convert the pond to a tertiary effluent storage pond, installation of a new pipeline connecting the Tertiary Effluent Pump Station and the Tertiary Effluent Storage Pond, rerouting the existing storm water drain line to the Out-of-Compliance Ponds, installation of a new stormwater pump station, modifications to the OOC diversion, and associated electrical, instrumentation, and control system modifications.

B. Except as specifically noted otherwise, provide and pay for:
   1. Insurance and bonds.
   2. Labor, materials, and equipment.
   3. Tools, equipment, and machinery required for construction.
   4. Utilities required for construction.
   5. Temporary facilities including sheeting and shoring.
   6. Traffic control and dust control measures.
   7. Other facilities and services necessary for proper execution and completion of the Work.

C. Secure and pay for all permits including OSHA excavation permits, Department of Transportation permits, government fees, and licenses.

D. Comply with codes, ordinances, regulations, orders, and other legal requirements of public authorities having bearing on the performance of the Work.

1.03 LOCATION OF PROJECT

A. The Work is located at 17140 Kitching Street, Moreno Valley, CA 92588.
1.04 DISTRICT-FURNISHED EQUIPMENT

A. District will furnish the following products:
   1. PLC5 Analog Input Card.

1.05 ACTIVITIES BY OTHERS

A. District, utilities, and others may perform activities within Project area while the Work is in progress.
   1. Schedule the Work with District, utilities, and others to minimize mutual interference.

B. Activities by others which may affect performance of work include:
   1. Plant Operation

C. Cooperate with others to minimize interference and delays.
   1. When cooperation fails, submit recommendations and perform Work in coordination with work of others.

D. When the Work depends for proper execution or results upon work performed by others, inspect and promptly report apparent discrepancies or defects in work performed by others.
   1. Assume responsibility for work performed by others, except for defects reported as specified in this paragraph and defects that may become apparent in work performed by others after execution of the Work.

1.06 COORDINATION OF WORK

A. Contractor shall have a preconstruction video made that records the project sites (with the Engineer and District present) including all concrete and asphalt pavements, curb and gutter, fencing to remain, structures to be demolished, and existing structures and facilities that are to be modified.
   1. The original and 2 copies of the DVD shall be turned over to Engineer and District prior to beginning construction activities.
   2. The format of the video file on the DVD shall be 1 file that can be played on a desktop in the windows media player.
   3. The video shall clearly identify existing site and structural conditions prior to construction.

B. Maintain overall coordination of the Work.

C. Obtain construction schedules from each subcontractor, and require each subcontractor to maintain schedules and coordinate modifications.

1.07 EARLY OCCUPANCY OF PORTIONS OF WORK

A. District's partial utilization of portions of work prior to final acceptance of the completed work will be made as described in Section 01140 – Work Restrictions.
PART 2 PRODUCTS
Not Used.

PART 3 EXECUTION
Not Used.

END OF SECTION
SECTION 01116

CONTRACT DOCUMENT LANGUAGE

PART 1  GENERAL

1.01  SUMMARY

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

1.02  REFERENCES

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

1.03  PROJECT MANUAL ARRANGEMENT

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

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

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

1.04  CONTRACT DOCUMENT LANGUAGE

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

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

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

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

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

G. Words "Contractor shall" are implied when direction is stated in imperative mood.

H. Term "products" includes materials and equipment as specified in Section 01600 - Product Requirements.

PART 2 PRODUCTS
Not Used.

PART 3 EXECUTION
Not Used.

END OF SECTION
SECTION 01140

WORK RESTRICTIONS

PART 1  GENERAL

1.01 SUMMARY

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

1.02 SUBMITTALS

A. Baseline Schedule with MOP tasks.
B. Progress Schedule with MOP tasks.

1.03 GENERAL CONSTRAINTS ON SEQUENCE AND SCHEDULING OF WORK

A. Wastewater projects:
   1. The Moreno Valley Regional Water Reclamation Facility (MVRWRF) treats domestic and industrial wastewater prior to discharge. Impairing the operational capabilities of the treatment facility will result in serious environmental damage and monetary fines.
   2. Conduct work in a manner that will not impair the operational capabilities of essential elements of the treatment process or reduce the capacity of the entire treatment plant below levels sufficient to treat the quality of raw wastewater to the water quality limitations specified in the discharge permit.
   3. Conduct commissioning and process start-up activities as specified in Section 01756 - Commissioning in a manner that will not impair the operational capabilities of essential elements of the treatment process or reduce the capacity of the entire treatment plant below levels sufficient to treat the quality of raw wastewater to the water quality limitations specified in the discharge permit.
   4. The status of the treatment plant shall be defined as "operational" when it is capable of treating the entire quantity of wastewater received to the water quality limits specified in the discharge permit.
   5. Work sequence and constraints.
   6. Utilize description of critical events in work sequence in this Section as a guideline for scheduling and undertaking the Work.
   7. Work sequence and constraints presented do not include all items affecting completion of the Work; they are intended to describe critical events necessary to minimize disruption of the existing facilities and to ensure compliance with permit requirements.
1.04 SHUTDOWN AND CONSTRUCTION CONSTRAINTS

A. General shutdown constraints:
   1. Execute the Work while the existing facility is in operation.
   2. Some activities may be accomplished without a shutdown.
   3. Apply to activities of construction regardless of process or work area.
   4. Activities that disrupt plant or utilities operations must comply with these shutdown constraints.
   5. Organize work to be completed in a minimum number of shutdowns.
   6. Provide thorough advanced planning, including having required equipment, materials, and labor on hand at time of shutdown.
   7. Where required to minimize treatment process interruptions while complying with specified sequencing constraints, provide temporary pumping, power, lighting, controls, instrumentation, and safety devices.
   8. Final determination of the permitting of shutdowns will be the sole judgment of the District.
   9. District maintains the ability to abort on the day of the scheduled shutdown.

B. Unit process availability work limitations:
   1. Shutdowns and tie-ins or other activities that disrupt plant operations are prohibited unless the following unit process availability conditions exist and unless otherwise approved in writing by the Engineer.

C. Shutdown activities:
   1. Tertiary Effluent Pump Station Shutdown:
      a. For all work to be completed outside of the Tertiary Effluent Pump Station, as indicated in the Drawings and Specifications, Contractor shall be allowed two shutdowns of the tertiary process for 24 hours:
         1) The shutdown will include works to substantially complete the work to make final connections between the new Tertiary Effluent Storage Pond and the Tertiary Effluent Pump Station.
         2) Liquidated damages will be imposed if the Tertiary Effluent Pump Station is not functional after the allotted shutdown duration (SC-06).
      b. Scheduling:
         1) Contractor shall notify Engineer at least 1 month in advance.
         2) Two weeks prior to the scheduled shutdown, Contractor shall schedule a meeting with the Engineer and District to verify shutdown schedule and work sequence.
         3) Minimum of 2 weeks between shutdowns.
   2. Chlorine Contact Basins North Effluent Box:
      a. For all work to be completed outside of the Chlorine Contact Basin 3 (CCB 3) Effluent Box, as indicated on the Drawings and Specifications, Contractor shall be allowed one shutdown of the CCB 3 for one week:
         1) Prior to the shutdown, install temporary plug in the pipe connecting the CCB 3 and the South Effluent Box.
2) The shutdown will include works to substantially complete the work to make final connections between the CCBs North Effluent Box and the Out of Compliance diversion pipe.

3) Liquidated damages will be imposed if the OOC diversion is not functional after the allotted shutdown duration (SC-06).

b. Scheduling:
   1) Contractor shall notify Engineer at least 1 month in advance.
   2) Two weeks prior to the scheduled shutdown, Contractor shall schedule a meeting with the Engineer and District to verify shutdown schedule and work sequence.

3. Chlorine Contact Basins South Effluent Box:
   a. For all work to be completed outside of the Chlorine Contact Basins South Effluent Box, as indicated on the Drawings and Specifications, Contractor shall be allowed one shutdown of all the CCBs for 24 hours:
      1) The shutdown will include works to substantially complete the installation of stainless slide gate for isolating the tertiary effluent from the Tertiary Effluent Pump Station.
      2) Liquidated damages will be imposed if the isolation gate is not functional after the allotted shutdown duration (SC-06).
   b. Scheduling:
      1) Contractor shall notify Engineer at least 1 month in advance.
      2) Two weeks prior to the scheduled shutdown, Contractor shall schedule a meeting with the Engineer and District to verify shutdown schedule and work sequence.

4. This Section does not include unplanned shutdowns due to emergencies.

D. Dewatering of existing process and disposal of residue:
   1. When the District has turned the process unit over to the Contractor for modification or temporary use, the Contractor is responsible for costs and procedures required to dewater and dispose of liquid, solids, etc. in the process unit.
      a. Drainage and disposal of process unit liquids, solids, etc. into another treatment process unit on the plant site may be allowed if approved in advance by the Engineer and District, and is conducted in accordance with District’s requirements.
      b. Costs for dewatering, disposal of solids and residuals, and preparation of surfaces for the Work are Contractor’s responsibility.
         1) Includes hauling and tipping fees for the removal and disposal of the grit/debris.
      c. Dewatering of grit/debris to meet landfill requirements is the responsibility of the Contractor.
      d. Contractor shall provide adequate time in schedules for draining and cleanup of basins and channels.
E. Process area construction constraints:
   1. The following sequences and constraints shall be observed while working in
      and around each of the following process areas.
      a. Tertiary Effluent Pump Station:
         1) Final connections of the Tertiary Effluent pipe to the Tertiary Effluent
            Pump Station shall be done during a shutdown of the tertiary
            process.
      b. Tertiary Effluent Equalization Pond and Storm Water Pump Station:
         1) The Storm Water Pump Station (Drawing Number 24M01) and storm
            water pipeline (Drawing Number 01C10) shall be constructed and
            operational prior to construction of the Tertiary Effluent Storage
            Pond (Drawing Numbers 01C04 and 01C05).
         2) Modifications to the existing storm water pipeline (Drawing
            Number 01C17, Detail U) shall be performed between the months of
            June and October.
         3) Provide 3-week notice prior to beginning work on the Tertiary
            Effluent Equalization Pond.
      c. Material hauling operations:
         1) Contractor shall comply with restrictions regarding Contractor’s use
            of site and premises as specified in Section 01110 - Summary of
            Work.

1.05 METHOD OF PROCEDURE (MOP)

A. MOP Instructions: See Appendix A.

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

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

D. Submit Baseline Schedule, as specified in Section E01310 – Project Control Schedule
   with proposed MOPs.

E. Submit MOP Log at construction progress meetings.

F. No consideration will be given to claims of additional time and cost associated to
   preparing MOPs required by the District and Engineer to complete this work in a
   manner that facilitates proper operation of the facility and compliance with
   effluent discharge criteria.
G. Where required to minimize treatment process interruptions while complying with specified sequencing constraints, provide temporary pumping, power, lighting, controls, instrumentation, and safety devices.

1.06 COMPLIANCE WITH NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM PERMIT

A. The existing facility is operating under the terms of permits issued by the California Regional Water Quality Control Board (Order No. R8-2006-0007, Order No. 88-94). This permit specifies the water quality limits that the plant must meet prior to discharge of effluent. The existing facilities are operating under the terms of a Title V air quality permit. This permit specifies the pollution emissions from point and fugitive sources within the facility; the plant must meet the conditions specified in the permit at all times.

B. Perform work in a manner that will not prevent the existing facility from achieving the finished water quality requirements established by regulations.

C. Bear the cost of penalties imposed on the District for discharge violations caused by actions of the Contractor.

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

A. Conduct the Work and provide temporary facilities required to keep the existing plant continuously operational.

B. Do not remove or demolish existing facilities required to keep the existing plant operational at the capacities specified until the existing facilities are replaced by temporary, new, or upgraded facilities or equipment.
   1. Test replacement facilities to demonstrate operational success prior to removing or demolishing existing facilities.

1.08 OPERATIONS AND MAINTENANCE ACCESS

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

1.09 UTILITIES

A. Provide advance notice to and utilize services of Underground Services Alert (U.S.A.) for location and marking of underground utilities operated by utility agencies other than the District. Also notify in advance the EMWD Locations Facility Department for marking of underground utilities inside EMWD facility.

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

1.10 COORDINATION OF WORK

A. Maintain overall coordination of the Work.

B. Obtain construction schedules from subcontractors and suppliers, and assume responsibility for correctness.

C. Incorporate schedules from subcontractors and suppliers into Progress Schedule to plan for and comply with sequencing constraints.

1.11 WORK BY OTHERS

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

1.12 TEMPORARY SERVICES, MATERIALS, AND EQUIPMENT

A. As specified in Section 01500 – Temporary Facilities and Controls.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION
APPENDIX A

“Method of Procedure” (MOP)

Definitions and Forms

DEFINITION AND PURPOSE

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

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

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

MOP PROCESS SUMMARY

<table>
<thead>
<tr>
<th>Who</th>
<th>Step</th>
<th>Timing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contractor</td>
<td>1. Identify MOPs needed on MOP Log and Baseline Schedule.</td>
<td>7 days prior to Preconstruction Scheduling Meeting</td>
</tr>
<tr>
<td>Contractor</td>
<td>2. Pre-MOP Meeting.</td>
<td>More than 28 days prior to work</td>
</tr>
<tr>
<td>Contractor</td>
<td>3. Submits MOP.</td>
<td>No later than 28 days prior to work</td>
</tr>
<tr>
<td>District</td>
<td>4. Reviews MOP.</td>
<td></td>
</tr>
<tr>
<td>District</td>
<td>5. MOP finalized.</td>
<td>7 days prior to work</td>
</tr>
<tr>
<td>Contractor</td>
<td>6. Complete Readiness Checklist.</td>
<td>5 days prior to work</td>
</tr>
<tr>
<td>Contractor</td>
<td>7. Complete Safety Checklist.</td>
<td>Just prior to commencing work</td>
</tr>
<tr>
<td>Contractor</td>
<td>9. Update MOP Log and Progress Schedules.</td>
<td>Monthly</td>
</tr>
</tbody>
</table>
MOP PROCESS DETAIL

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

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

STEP 2. Pre-MOP Meeting

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

STEP 3. Submits MOP.

Contractor completes the MOP Form and submits 3 copies for approval to the District’s Project Manager.

STEP 4. Reviews MOP.

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

STEP 5. MOP finalized.

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


Contractor verifies everything is ready for the work.


Contractor ensures safety.

STEP 8. Complete work.

Contractor complete work.

STEP 9. Update MOP Log and Progress Schedules.

Contractor updates MOP Log weekly and distributes at the regularly scheduled construction progress meetings.
**METHOD OF PROCEDURE (MOP) FORM**

<table>
<thead>
<tr>
<th>Owner:</th>
<th>Date:</th>
<th>Contractor:</th>
<th>Carollo Project No.:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Project Name:</th>
<th>Submittal No.:</th>
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</thead>
<tbody>
<tr>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Submittal Title:</th>
<th>Spec/Dwg. Reference:</th>
</tr>
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<tbody>
<tr>
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</table>

<table>
<thead>
<tr>
<th>MOP #</th>
<th>Task Title (Provide &lt;10 word title):</th>
<th>Submittal Date: (No later than 28 days prior to work)</th>
</tr>
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<tbody>
<tr>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>SCHEDULE OF WORK ACTIVITY START: (Date/Time)</th>
<th>END: (Date/Time)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>REQUESTOR:</th>
</tr>
</thead>
<tbody>
<tr>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PRIMARY POINT OF CONTACT:</th>
<th>PHONE/PAGER:</th>
</tr>
</thead>
<tbody>
<tr>
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<table>
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<table>
<thead>
<tr>
<th>NOTIFY</th>
<th>Control Room, Phone</th>
<th>Security, Phone</th>
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</thead>
<tbody>
<tr>
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<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>BUILDING:</th>
<th>LOCATION OF WORK FLOOR/LEVEL:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Task Summary:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Processes Affected:</th>
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<tbody>
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<table>
<thead>
<tr>
<th>Trades Affected:</th>
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<tbody>
<tr>
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**WORK PLAN:**

<table>
<thead>
<tr>
<th>Work Sequencing:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Process Isolation:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Spill Prevention Plan:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Contingency Plans:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Acoustic Ceiling/or Walls Access</th>
<th>Excavation Permit</th>
<th>Lock Out/Tag Out</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<table>
<thead>
<tr>
<th>Chemical Use Approval</th>
<th>Fire Sprinkler Impairment</th>
<th>Life Safety Systems</th>
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<td></td>
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<table>
<thead>
<tr>
<th>Confined Space Permit</th>
<th>Flammable Materials</th>
<th>Roof Protocol</th>
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<table>
<thead>
<tr>
<th>Critical Lift Plan</th>
<th>Flush/Discharge</th>
<th>Work After Dark</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<table>
<thead>
<tr>
<th>Energized Electrical Work</th>
<th>High Pressure Test</th>
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<tbody>
<tr>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Elect. Panel Schedules</th>
<th>Hot Work/Open Flame</th>
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</thead>
<tbody>
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</table>

April 2020 01140-9 10546B10

pw:///Carollo/Documents/Client/CA/EMWD/10546B10/Specifications/01140 (Bid)
**EXISTING SERVICE(S) AT RISK:**

<table>
<thead>
<tr>
<th>Service</th>
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<th>Service</th>
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<th>Service</th>
<th></th>
<th>Service</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Breathing Air</td>
<td></td>
<td>Elect Normal</td>
<td></td>
<td>Process Access</td>
<td></td>
<td>Telephones</td>
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</tr>
<tr>
<td>Chemical Distribution</td>
<td></td>
<td>Fire Protection</td>
<td></td>
<td>Safety Showers</td>
<td></td>
<td>UPS</td>
<td></td>
</tr>
<tr>
<td>City Water</td>
<td></td>
<td>HVAC</td>
<td></td>
<td>SCADA</td>
<td></td>
<td>VAX/DATA</td>
<td></td>
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<tr>
<td>Communication</td>
<td></td>
<td>Inert Gas</td>
<td></td>
<td>Security</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Domestic Drain</td>
<td></td>
<td>Instrument - Air</td>
<td></td>
<td>Solvent Drain</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elect-Bus Duct</td>
<td></td>
<td>Life Safety System</td>
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<td>Specialty Gases</td>
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<tr>
<td>Elect Emergency</td>
<td></td>
<td>Natural Gas</td>
<td></td>
<td>Storm Drain</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**REVIEWER’S INSTRUCTIONS/COMMENTS:**

**PREJOB BRIEFING MUST BE COMPLETED PRIOR TO COMMENCING WORK:**

<table>
<thead>
<tr>
<th>Submitted By</th>
<th>Full Name (printed)</th>
<th>Signature</th>
<th>Phone</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>System Owner</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reviewer (if needed)</td>
<td></td>
<td></td>
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<tr>
<td>Reviewer (if needed)</td>
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<tr>
<td>Reviewer (if needed)</td>
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<tr>
<td>Reviewer (if needed)</td>
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</tr>
</tbody>
</table>
READINESS CHECKLIST
(5 days prior to work)

Checklist provided as a guide but is not all-inclusive.

1. Confirm all parts and materials are on site: ________________________________

2. Review work plan: ________________________________

3. Review contingency plan: ________________________________
SAFETY CHECKLIST

(Just prior to commencing work)

Checklist provided as a guide but is not all-inclusive.

1. Location awareness:
   a. Emergency exits: ________________________________
   b. Emergency shower and eyewash: ________________________________
   c. Telephones and phone numbers: ________________________________
   d. Shut-off valve: ________________________________
   e. Electrical disconnects: ________________________________

2. Inspect work area:
   a. Take time to survey the area you are working in. Ensure that what you want to do will work. Do you have enough clearance? Is your footing secure? Do you have adequate lighting and ventilation? Are surrounding utilities out of the way for you to perform your work?

3. MSDS (Material Safety Data Sheets):
   a. Understand the chemicals and substances in the area you are working in by reading the MSDS.

4. Lockout/Tagout Procedure:
   a. Lockout/Tagout energy sources before beginning work.
   b. Make sure all valves associated with the work are locked out and tagged out on each side of the penetration.
   c. Make sure the lines are depressurized.

5. Overhead work:
   a. Use appropriate personal protective equipment; i.e., safety harness, lifeline, etc.
   b. Select appropriate tie-off points; i.e. structurally adequate, not a pipe or conduit, etc.
   c. Spotter assigned and in position.
   d. Pipe rack access; i.e., check design capacity, protective decking or scaffolding in place, exposed valves or electrical switches identified and protected.

6. Safety Equipment
   a. Shepherd’s hook.
   b. ARC flash protection
   c. Fire extinguisher
   d. Other: ________________________________

7. Accidents:
   a. Should accidents occur do not shut-off and do not attempt to correct the situation, unless you are absolutely positive that your action will correct the problem and not adversely affect other people or equipment:
8. Review Start-up documents:
   a. In the event the system is shutdown, the Control Center should have a working knowledge of the start-up procedures in order to deal effectively with unforeseen events.

9. Evacuation Procedures:
   a. Do not obstruct evacuation routes.
   b. Take time to survey the area for evacuation routes.
METHOD OF PROCEDURE (MOP) LOG

Sample

<table>
<thead>
<tr>
<th>MOP Number</th>
<th>Task Title</th>
<th>Date Requested</th>
<th>Date Approved</th>
<th>Date Work Planned</th>
<th>Work Completed (yes/no)</th>
</tr>
</thead>
<tbody>
<tr>
<td>001</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>002</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>003</td>
<td></td>
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</tbody>
</table>
SECTION 01353
SPECIAL PROCEDURES FOR LOCATING AND VERIFYING CONCEALED EXISTING UTILITIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Special procedures for locating and verifying concealed existing utilities.

1.02 CONCEALED EXISTING UTILITIES

A. Verify locations of utilities including utilities shown or noted as abandoned which may exist by consulting with the District, utility companies, and Underground Services Alert (USA) or other service available in area of Project:
   1. Abide by easement and right-of-way restrictions.

B. Perform exploratory vacuum excavation potholing, as necessary to more accurately identify location, depth, configuration, and utility service in congested utility areas prior to preparation of shop drawings and subsequent excavation.
   1. Potholing shall be backfilled immediately after purpose has been satisfied and the surface restored and maintained in a manner satisfactory to Engineer.
   2. Adjustments in construction methods shall be made to accommodate utility location information gained from potholing as necessary to protect existing utilities and maintain plant in operations.
   3. Note that installation of all underground yard piping and utilities in this project are considered to be installed in congested utility areas.
   4. Some variation from the conditions indicated on the Drawings is to be expected.

C. Notify the District and owners of facilities when the Work will be in progress.

D. Make arrangements for potential emergency repairs in accordance with requirements of owners of utility facilities, including individual or residential facilities.

E. Assume responsibility for repair of utilities and facilities damaged by performance of the Work.
F. Expose sanitary and storm sewers, water, gas, electric, telephone utility lines, and other underground facilities indicated to permit survey location prior to commencement of Work in affected area:
   1. Expose in ample time to permit relocation of interfering utilities with minimum delaying effect on Contract Time.

G. Work required for raising, lowering, or relocating utilities not indicated will be performed by affected utility owners or as part of the Work at option of affected owners of utilities:
   1. When part of the Work, perform work in accordance with standards of affected utility owner, and adjustment to Contract Price and Contract Times will be made as stipulated in conditions of Contract.

PART 2 PRODUCTS
Not Used.

PART 3 EXECUTION
Not Used.

END OF SECTION
SECTION 01410
REGULATORY REQUIREMENTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Regulatory authorities and codes.
   1. Building code.
   2. Electrical code.
   3. Energy code.
   4. Fire code.
   5. Mechanical code.
   6. Plumbing code.

1.02 REFERENCES

A. National Fire Protection Association (NFPA):

B. State or Local Building Codes and Amendments.
   1. California Code of Regulations (CCR):
      a. Title 24:- California Building Standards Code.
         1) California Building Code -2019 (CBC). (Title 24, Part 2.)
         2) California Electrical Code -2019 (CEC). (Title 24, Part 3.)
         3) California Mechanical Code -2019 (CMC). (Title 24, Part 4.)
         4) California Plumbing Code -2019 (CPC). (Title 24, Part 5.)
         5) California Fire Code -2019 (CFC). (Title 24, Part 9.)
         6) California Existing Building Code - 2019 (CEBC). (Title 24, Part 10.)

1.03 SYSTEM DESCRIPTION

A. Design requirements:
   1. Building code:
   2. Electrical code:
      b. California Electrical Code.
   3. Fire code:
   4. Mechanical codes:
   5. Plumbing code:
PART 2  PRODUCTS
Not used.

PART 3  EXECUTION
Not used.

END OF SECTION
SECTION 01424
ABBREVIATIONS AND ACRONYMS

PART 1  GENERAL

1.01 SUMMARY

A. Section includes: Abbreviations and meanings.

1.02 INTERPRETATIONS

A. Interpret abbreviations by context in which abbreviations are used.

1.03 ABBREVIATIONS

A. Abbreviations used to identify reference standards:

- AA: Aluminum Association
- AABC: Associated Air Balance Council
- AAMA: Architectural Aluminum Manufacturers Association
- AAN: American Association of Nurserymen
- AASHTO: American Association of State Highway and Transportation Officials
- ABC: Associated Air Balance Council
- AATCC: American Association of Textile Chemists and Colorists
- ABMA: American Bearing Manufacturers' Association (formerly AFBMA, Anti-Friction Bearing Manufacturers' Association)
- ABPA: Acoustical and Board Products Association
- ACGIH: American Conference of Government Industrial Hygienists
- ACI: American Concrete Institute
- ACIL: American Council of Independent Laboratories
- ADC: Air Diffusion Council
- ABMA: American Bearing Manufacturers' Association (formerly AFBMA, Anti-Friction Bearing Manufacturers' Association)
- AGA: American Gas Association
- AGC: Associated General Contractors
-AGMA: American Gear Manufacturers' Association
- AHRI: Air-Conditioning, Heating, and Refrigeration Institute
- AI: Asphalt Institute
- AIA: American Institute of Architects
- AIMA: Acoustical and Insulating Materials Association
- AISC: American Institute of Steel Construction
- AISI: American Iron and Steel Institute
- AITC: American Institute of Timber Construction
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMG</td>
<td>Arizona Masonry Guild</td>
</tr>
<tr>
<td>ANSI</td>
<td>American National Standards Institute</td>
</tr>
<tr>
<td>APA</td>
<td>American Plywood Association</td>
</tr>
<tr>
<td>API</td>
<td>American Petroleum Institute</td>
</tr>
<tr>
<td>ASAHC</td>
<td>American Society of Architectural Hardware Consultants</td>
</tr>
<tr>
<td>ASCE</td>
<td>American Society of Civil Engineers</td>
</tr>
<tr>
<td>ASHRAE</td>
<td>American Society of Heating, Refrigeration and Air Conditioning Engineers</td>
</tr>
<tr>
<td>ASME</td>
<td>American Society of Mechanical Engineers</td>
</tr>
<tr>
<td>ASTM</td>
<td>ASTM International</td>
</tr>
<tr>
<td>AWI</td>
<td>Architectural Woodwork Institute</td>
</tr>
<tr>
<td>AWPA</td>
<td>American Wood Protection Association</td>
</tr>
<tr>
<td>AWPI</td>
<td>American Wood Preservers Institute</td>
</tr>
<tr>
<td>AWS</td>
<td>American Welding Society</td>
</tr>
<tr>
<td>AWSC</td>
<td>American Welding Society Code</td>
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<td>American Water Works Association</td>
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<td>BHMA</td>
<td>Builders Hardware Manufacturers Association</td>
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<td>BIA</td>
<td>Brick Institute of America</td>
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<td>BSI</td>
<td>Building Stone Institute</td>
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<td>California Department of Transportation</td>
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<td>Cal-OSHA</td>
<td>California Occupational Safety and Health Administration</td>
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<td>California Code of Regulations</td>
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<td>Carpet and Rug Institute</td>
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<td>CRSI</td>
<td>Concrete Reinforcing Steel Institute</td>
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<td>Commercial Standards</td>
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<td>Construction Specifications Institute</td>
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<tr>
<td>DHI</td>
<td>Door and Hardware Institute</td>
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<td>EIFS</td>
<td>Exterior Insulation and Finish System</td>
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<td>Food and Drug Administration</td>
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<td>Factory Insurance Association</td>
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<td>International Code Council</td>
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<td>National Asphalt Pavement Association</td>
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<td>National Environmental Balancing Bureau</td>
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<td>National Forest Products Association</td>
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<td>National Institute for Occupational Safety and Health</td>
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<td>National Paint and Coatings Association</td>
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<td>Full Name</td>
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<td>National Terrazzo and Mosaic Association</td>
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<td>Prestressed Concrete Institute</td>
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<td>Paint and Decorating Contractors of America</td>
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<td>Plumbing and Drainage Institute</td>
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<td>Porcelain Enamel Institute</td>
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<td>PS</td>
<td>Product Standard</td>
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<td>Research Council on Structural Connections</td>
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<td>RILEM</td>
<td>International Union of Testing and Research Laboratories for Materials and Structures</td>
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<td>Resilient Tile Institute</td>
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<td>SAE International</td>
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<td>Sealed Insulating Glass Manufacturers Association</td>
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<td>Society for Protective Coatings</td>
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<td>U.S. Army Corps of Engineers</td>
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<td>Vermiculite Association</td>
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<td>West Coast Lumber Inspection Bureau</td>
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<td>Western Pine Association</td>
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<td>Western Plumbing Officials Association</td>
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<td>Welding Research Council</td>
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<td>WWPA</td>
<td>Western Wood Products Association</td>
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B. Abbreviations used in Specifications and Drawings:

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<th>Description</th>
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<td>ampere or amperes</td>
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<td>ante meridian (before noon)</td>
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<td>alternating current</td>
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<td>acre-foot or acre-feet</td>
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<td>atm</td>
<td>atmosphere</td>
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<td>AWG</td>
<td>American Wire Gauge</td>
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<td>barrel or barrels</td>
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<td>board</td>
</tr>
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<td>bhp</td>
<td>brake horsepower</td>
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<td>BIL</td>
<td>basic impulse insulation level</td>
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<td>billion gallons</td>
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<td>biochemical oxygen demand</td>
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<td>Btu</td>
<td>British thermal unit or units</td>
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<td>Btuh</td>
<td>British thermal units per hour</td>
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<td>bushel or bushels</td>
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<td>bed volume(s)</td>
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<td>capita</td>
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<td>cfm</td>
<td>cubic feet per minute</td>
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<tr>
<td>Ci</td>
<td>curie or curies</td>
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<td>Cured-in-Place Pipe</td>
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<td>cm</td>
<td>centimeter or centimeters</td>
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<td>cmu</td>
<td>concrete masonry unit</td>
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<td>carbon monoxide</td>
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<td>Co.</td>
<td>Company</td>
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<td>carbon dioxide</td>
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<td>Corporation</td>
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<td>cubic feet per hour</td>
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<tr>
<td>cu ft/min</td>
<td>cubic feet per minute</td>
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<tr>
<td>cu ft/sec</td>
<td>cubic feet per second</td>
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<td>cu in</td>
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<td>cu m</td>
<td>cubic meter or meters</td>
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<td>Abbreviation</td>
<td>Description</td>
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<td>cu yd</td>
<td>cubic yard or yards</td>
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<td>day (metric units)</td>
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<td>day</td>
<td>day (English units)</td>
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<tr>
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<td>decibels</td>
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<td>D/d</td>
<td>column diameter to particle diameter ratio</td>
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<td>DB</td>
<td>dry bulb (temperature)</td>
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<td>direct current</td>
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<td>diameter</td>
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<td>dissolved solids</td>
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<td>empty bed contact time</td>
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<td>feet per minute</td>
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<td>foot-candle or foot candles</td>
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<td>feet per day</td>
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<td>feet per hour</td>
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<td>ft/min</td>
<td>feet per minute</td>
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<td>ft/sec</td>
<td>feet per second</td>
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<td>gram or grams</td>
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<td>Symbol</td>
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<td>hp</td>
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<td>input/output</td>
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<td>joule or joules</td>
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<td>JTU</td>
<td>Jackson turbidity unit or units</td>
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<td>k</td>
<td>kips</td>
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<td>kelvin</td>
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<td>L/D Ratio</td>
<td>Ratio of filter height to filter media particle diameter</td>
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<td>linear, lineal</td>
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<td>lin ft</td>
<td>linear foot or feet</td>
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<td>Abbreviation</td>
<td>Definition</td>
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<td>N</td>
<td>normal (concentration)</td>
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<td>National Pipe Thread</td>
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<td>NRC</td>
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<td>NTU or ntu</td>
<td>nephelometric turbidity unit</td>
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<td>pascal or pascals</td>
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<td>pl</td>
<td>plate or property line</td>
</tr>
<tr>
<td>pm</td>
<td>post meridiem (afternoon)</td>
</tr>
<tr>
<td>ppb</td>
<td>parts per billion</td>
</tr>
<tr>
<td>ppm</td>
<td>parts per million</td>
</tr>
<tr>
<td>ppt</td>
<td>parts per thousand</td>
</tr>
<tr>
<td>pr</td>
<td>pair</td>
</tr>
<tr>
<td>psf/hr</td>
<td>pounds per square foot per hour</td>
</tr>
<tr>
<td>psf</td>
<td>pounds per square foot</td>
</tr>
<tr>
<td>psi</td>
<td>pounds per square inch</td>
</tr>
<tr>
<td>psia</td>
<td>pounds per square inch absolute</td>
</tr>
<tr>
<td>psig</td>
<td>pounds per square inch gauge</td>
</tr>
<tr>
<td>PVC</td>
<td>polyvinyl chloride</td>
</tr>
<tr>
<td>qt</td>
<td>quart or quarts</td>
</tr>
<tr>
<td>R</td>
<td>radius</td>
</tr>
<tr>
<td>R</td>
<td>roentgen or roentgens</td>
</tr>
<tr>
<td>rad</td>
<td>radiation absorbed dose</td>
</tr>
<tr>
<td>RH</td>
<td>relative humidity</td>
</tr>
<tr>
<td>rpm</td>
<td>revolutions per minute</td>
</tr>
<tr>
<td>rps</td>
<td>revolutions per second</td>
</tr>
<tr>
<td>s</td>
<td>second (metric units)</td>
</tr>
<tr>
<td>S</td>
<td>Siemens (mho)</td>
</tr>
<tr>
<td>scfh</td>
<td>standard cubic feet per hour</td>
</tr>
<tr>
<td>scfm</td>
<td>standard cubic feet per minute</td>
</tr>
<tr>
<td>SDI</td>
<td>sludge density index or silt density index</td>
</tr>
</tbody>
</table>
sec  second (English units)
SI  International System of Units
sp  static pressure
sp gr  specific gravity
sp ht  specific heat
sq  square
sq cm2 or sq cm  square centimeter or centimeters
sq ft  square feet or foot
sq inch  square inch
sq inches  square inches
km2 or sq km  square kilometer or kilometers
m2 or sq m  square meter or meters
mm2 or sq mm  square millimeter or millimeters
sq yd  square yard or yards
SS  suspended solids
STC  Sound Transmission Class
SVI  sludge volume index
TDS  total dissolved solids
TEFC  totally enclosed, fan-cooled
TKN  total Kjeldahl nitrogen
TLM  median tolerance limit
TOC  total organic carbon
TOD  total oxygen demand
TOW  top of weir
TS  total solids
TSS  total suspended solids
TVS  total volatile solids
U  U Factor/U Value
U  Coefficient of Heat Transfer
U  heat transfer coefficient
UNS  Uniform Numbering System
US  United States
V  volt or volts
VA  volt-ampere or volt-amperes
W  watt or watts
WB  wet bulb
wg  water gauge
wk  week or weeks
WRT  water remediation technologies
wt  weight
yd  yard or yards
yr  year or years (English unit)

C. Abbreviations used on Drawings: As listed on Drawings or in Specifications.

PART 2   PRODUCTS
Not Used.

PART 3   EXECUTION
Not Used.

END OF SECTION
SECTION 01450
QUALITY CONTROL

PART 1 GENERAL

1.01 SUMMARY

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

1.02 QUALITY CONTROL AND CONTROL OF INSTALLATION

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

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

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

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

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

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

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

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

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

1.03 TOLERANCES

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

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

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

D. Comply with tolerances specified in other Sections.

1.04 REFERENCES


1.05 PRODUCT REQUIREMENTS

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

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

C. Obtain copies of standards where required by product Specification Sections.

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

1.06 MOCK-UP REQUIREMENTS

A. Tests will be performed under provisions identified in this Section and identified in respective product Specification Sections.

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

C. Accepted mock-ups shall be comparison standard for remaining Work.
D. Where mock-up has been accepted by Engineer and is specified in product Specification Sections to be removed; remove mock-up and clear area when directed to do so by Engineer.

1.07 AUTHORITY AND DUTIES OF DISTRICT'S REPRESENTATIVE OR INSPECTOR

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

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

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

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

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

1.08 SAMPLING AND TESTING

A. General:
   1. Prior to delivery and incorporation in the Work, submit listing of sources of materials, when specified in Sections where materials are specified.
   2. When specified in Sections where products are specified:
      a. Submit sufficient quantities of representative samples of character and quality required of materials to be used in the Work for testing or examination.
      b. Test materials in accordance with standards of national technical organizations.
B. Sampling:
   1. Furnish specimens of materials when requested.
   2. Do not use materials that are required to be tested until testing indicates satisfactory compliance with specified requirements.
   3. Specimens of materials will be taken for testing whenever necessary to determine quality of material.
   4. Assist Engineer in preparation of test specimens at site of work, such as soil samples and concrete test cylinders.

C. Test standards:
   1. Perform sampling, specimen preparation, and testing of materials in accordance with specified standards, and when no standard is specified, in accordance with standard of nationally recognized technical organization.
   2. Physical characteristics of materials not particularly specified shall conform to standards published by ASTM, where applicable.

1.09 TESTING AND INSPECTION SERVICES

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

B. District will employ and pay for specified services of an “District’s independent testing firm” to perform testing and inspection as required in the technical specifications for various work and materials or stipulated in Section 01455B - Special Tests and Inspections to confirm Contractor’s compliance with Contract Documents to confirm Contractor’s compliance with Contract Documents. If Engineer or District’s independent testing firm is not properly certified to perform specialty inspections required by the building department, District will employ and pay for a quality specialty inspection firm to perform required testing and inspection.

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

D. The qualifications of laboratory that will perform the testing, contracted by the District or by the Contractor, shall be as follows:
   1. Has authorization to operate in the state where the project is located.
   4. Laboratory Staff: Maintain full time specialist on staff to review services.
   5. Testing Equipment: Calibrated at reasonable intervals with devices of accuracy traceable to National Bureau of Standards (NBS) or accepted values of natural physical constants.
6. Will submit copy of report of inspection of facilities made by Materials Reference Laboratory of NBS during most recent tour of inspection, with memorandum of remedies of deficiencies reported by inspection.

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

F. Reports will be submitted by District’s independent testing firm to Engineer, Contractor, and District in triplicate, indicating observations and results of tests and indicating compliance or non-compliance with Contract Documents. Each report shall include:
   1. Date issued.
   2. Project title and number.
   3. Testing laboratory name, address, and telephone number.
   4. Name and signature of laboratory inspector.
   5. Date and time of sampling or inspection.
   6. Record of temperature and weather conditions.
   7. Date of test.
   8. Identification of product and Specification Section.
   9. Location of sample or test in Project.
   10. Type of inspection or test.
   11. Results of tests and compliance with Contract Documents.
   12. Interpretation of test results, when requested by Engineer.

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

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

I. Testing and employment of a District’s independent testing firm or laboratory shall not relieve Contractor of obligation to perform Work in accordance with requirements of Contract Documents.
J. Re-testing or re-inspection required because of non-conformance to specified requirements shall be performed by same District’s independent testing firm on instructions by Engineer. Payment for re-testing or re-inspection will be charged to Contractor by deducting testing charges from Contract Sum/Price.

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

L. District’s independent testing firm individual test reports: After each test, District’s independent testing firm will promptly submit electronically and three hard copies of report to Engineer and to Contractor. When requested by Engineer, the District’s independent testing firm will provide interpretation of test results. Include the following:
   1. Date issued.
   2. Project title and number.
   3. Name of inspector.
   4. Date and time of sampling or inspection.
   5. Identification of product and Specifications Section.
   6. Location in Project.
   7. Type of inspection or test.
   8. Date of test.
   9. Certified test results stamped and signed by an Engineer registered in the State of California.
   10. Summary of conformance with Contract Documents.
   11. When requested by Engineer, the District’s independent testing firm will provide interpretation of test results.

M. District’s independent testing firm will provide monthly report of certification to identify all work performed for special inspections and other contract requirements on this project. The following certified monthly report at a minimum will include but not limited to:
   1. Results of testing.
   2. Testing logs.
   3. Outstanding deficiencies.
   4. Various statistical data.
   5. Testing curves (up to 4 types) as required by the Engineer.
1.10 CONTRACTOR'S RESPONSIBILITIES

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

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

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

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

E. Furnish incidental labor and facilities:
   1. To provide access to construction to be tested.
   2. To obtain and handle samples at Work site or at source of product to be tested.
   3. To facilitate inspections and tests.
   4. For storage and curing of test samples.

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

PART 2 PRODUCTS
Not Used.

PART 3 EXECUTION
Not Used.

END OF SECTION
SECTION 01455B

SPECIAL TESTS AND INSPECTIONS

1.01 SUMMARY

A. Section includes: This Section describes the requirements for providing special inspections, special tests, and structural observation.

1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. 318 - Building Code Requirements for Structural Concrete.

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

C. American Society of Civil Engineers (ASCE):

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

E. ASTM International (ASTM):
   2. C31 - Standard Practice for Making and Curing Concrete Test Specimens in the Field.

F. California Building Code (CBC).

1.03 DEFINITIONS

A. Special Inspection: Inspection of the materials, installation, fabrication, erection, or placement of components and connections requiring special expertise to ensure compliance with approved construction documents and referenced standards.

B. Special Inspection, Continuous: The full-time observation of work requiring special inspection by an approved special inspector who is present in the area where the work is being performed.
C. Special Inspection, Periodic: The part-time or intermittent observation of work requiring special inspection by an approved special inspector who is present in the area where the work is being performed and at the completion of the work.

D. Structural Observation: The visual observation of the structural system by a registered design professional for general conformance to the approved construction documents at significant construction stages and at completion of the structural system.

1.04 DESCRIPTION

A. This Section describes special inspections, special tests, and structural observation of structural assemblies and components to be performed in compliance with the regulatory building code specified in Section 01410 - Regulatory Requirements.

B. These special tests and inspections are in addition to the requirements specified in Section 01450 - Quality Control, and by the individual Sections.

1.05 SPECIAL INSPECTION

A. District will employ 1 or more special inspectors who will provide special inspections during construction.

B. Special inspectors shall be qualified for inspection of the particular type of materials or operations requiring special inspection.

C. Duties of Special Inspector:
   1. General: Required duties of the special inspector(s) shall be as described in Chapter 17 of the building code, specified in Section 01410 - Regulatory Requirements, and this Section.
   2. Reporting: Special inspector(s) shall provide reports of each inspection to the District. District shall distribute copies of inspection reports to the Contractor.
      a. Reports shall, at a minimum, indicate the following items:
         1) Date and time of inspection, and name(s) of individual(s) performing the inspection.
         2) Structures and areas of the structure where work or testing was observed.
         3) Discrepancies between the requirements of the Contract Documents and the work or testing observed.
         4) Other areas of deficiency in the Work.

D. Special inspections shall not be construed as fulfilling the requirements for structural observation.
1.06 TESTING

A. Testing laboratory: Special tests will be performed by District's testing laboratory as specified in Section 01450 - Quality Control.

B. Selection of the material to be tested shall be by Engineer or by District's testing laboratory, and not by the Contractor.

1.07 STRUCTURAL OBSERVATION

A. District will employ 1 or more registered design professionals who will provide structural observation during construction.
   1. Registered design professional shall be a civil or structural engineer currently licensed as such in the state of California and regularly engaged in the structural design of structures equivalent or similar to those indicated on the Drawings.

B. Structural observations shall not be construed as fulfilling the requirements for special inspections.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 SPECIAL TESTING AND INSPECTIONS

A. The following types of work require special inspection as described in Section 1705 of the building code as specified in Section 01410 - Regulatory Requirements and shall be provided wherever such work occurs unless otherwise specified. Refer to the following schedules:
   1. Appendix A: Concrete Special Inspection Schedule.
   2. Appendix B: Architectural, Mechanical, and Electrical Component Special Inspection Schedule.
   3. Appendix C: Soils Verification and Inspection Schedule.

B. Testing and qualification for seismic resistance (Section 1705.12 of the regulatory building code):
   1. The following designated systems shall be subject to the testing and qualification requirements of Section 1705.12.3 of the regulatory building code and shall require special certification as set forth in ASCE 7, Section 13.2:
      a. Mechanical equipment with an importance factor of 1.50 as specified in Section 01612 - Seismic Design Criteria.
      b. All electrical equipment.
2. Seismic certification requirements for designated systems:
   a. Submittals for mechanical and electrical equipment identified in this Section as designated systems shall include certification that the equipment is seismically qualified. Certifications shall be subject to review and acceptance by the Contractor.
      1) Certifications may be at least 1 of the following in accordance with ASCE 7, Section 13.2:
         a) Analysis.
         b) Testing.
         c) Experience data.
   b. Special inspector shall examine the designated seismic system and determine whether the designated system components, including anchorage, conform to the evidence of compliance submitted.

3.02 STRUCTURAL OBSERVATION

A. The following work requires structural observation in accordance with Section 1704.5 of the regulatory building code:
   1. All Structures in all Areas:
      a. Foundations.
      b. Slab on grade and equipment pads.
      c. Walls.

3.03 SCHEDULE

A. Contractor shall allow time necessary for Special Inspections as listed above.

B. Sufficient notice shall be given so that the Special Inspections can be performed. This includes time for off-site Special Inspectors to plan the inspection and travel to site.

3.04 PROCEDURE

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

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

END OF SECTION
## APPENDIX A

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

<table>
<thead>
<tr>
<th>Verification and Inspection</th>
<th>Reference Standard</th>
<th>Frequency of Inspection (During Task Listed)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Continuous</td>
</tr>
<tr>
<td><strong>1. Construction of forms.</strong></td>
<td>ACI 318: 26.13.3.3(c)</td>
<td><img src="image" alt="Periodic" /></td>
</tr>
<tr>
<td>a. Removal of slab forms and installation of re-shoring.</td>
<td>ACI 318: 26.13.3.2(c)</td>
<td><img src="image" alt="Periodic" /></td>
</tr>
<tr>
<td><strong>2. Inspection of reinforcing steel, including prestressing and post-tensioning tendons.</strong></td>
<td>ACI 318: Ch 20, 25.2, 25.3, 26.5.1-26.5.3, 26.13.3.3(a) CBC: 1908.4</td>
<td><img src="image" alt="Periodic" /></td>
</tr>
<tr>
<td>a. Reinforcement in &quot;special reinforced concrete moment frames.&quot;</td>
<td>ACI 318: 26.13.3.2(d)</td>
<td><img src="image" alt="Periodic" /></td>
</tr>
<tr>
<td>b. Reinforcing bar couplers and terminators:</td>
<td>Evaluation Service Reports</td>
<td><img src="image" alt="Periodic" /></td>
</tr>
<tr>
<td><strong>3. Inspection of reinforcing steel welding:</strong></td>
<td>AWS D1.4 ACI 318: 26.6.4.1</td>
<td><img src="image" alt="Periodic" /></td>
</tr>
<tr>
<td>a. Verify weldability of reinforcing bars (other than ASTM A706).</td>
<td>ACI 318: 26.6.4.1</td>
<td><img src="image" alt="Periodic" /></td>
</tr>
<tr>
<td>b. Single pass fillet welds (to 5/16 inch).</td>
<td>CBC: Table 1705.3</td>
<td><img src="image" alt="Periodic" /></td>
</tr>
<tr>
<td>c. All other welds.</td>
<td>CBC Table 1705.3</td>
<td><img src="image" alt="Periodic" /></td>
</tr>
<tr>
<td><strong>4. Inspect anchors and embedments cast into concrete (prior to and during placement of concrete).</strong></td>
<td>ACI 318: 17.8.2, 26.13.3.3(a)</td>
<td><img src="image" alt="Periodic" /></td>
</tr>
<tr>
<td>a. Adhesive anchors installed in horizontal or upwardly inclined orientations.</td>
<td>ACI 318: 17.8.2.4, 26.13.3.2(c). Evaluation Service Reports</td>
<td><img src="image" alt="Periodic" /></td>
</tr>
<tr>
<td>b. Mechanical anchors, and adhesive anchors not included under 4a.</td>
<td>ACI 318: 17.8.2, 26.13.3(f)</td>
<td><img src="image" alt="Periodic" /></td>
</tr>
<tr>
<td>Verification and Inspection</td>
<td>Reference Standard</td>
<td>Frequency of Inspection(1)</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>--------------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td></td>
<td>ACI 318-14 AWS D1.4-11</td>
<td>(During Task Listed)</td>
</tr>
<tr>
<td></td>
<td>CBC 2019</td>
<td>Continuous</td>
</tr>
</tbody>
</table>

6. Concrete placement:

a. Verify use of required mix design.  
   - ACI 318: Ch 19, 26.4.3, 26.4.4  
   - CBC: 1904.1, 1904.2, 1908.2, 1908.3

b. Sampling and preparation of cylinders and specimens for testing.  
   - ACI 318: 26.12  
   - CBC: 1908.10

c. At the time fresh concrete is sampled to fabricate specimens for testing, perform slump and air content tests, and determine the temperature of the concrete.  
   - ASTM C172  
   - ASTM C31  
   - ACI 318: 26.12  
   - CBC 1908.10

7. Inspection of concrete placement for proper application and consolidation techniques.  
   - ACI 318: 26.13.3.2(a)  
   - CBC: 1908.6, 1908.7, 1908.8

8. Inspection for maintenance of specified curing temperatures, techniques, and duration.  
   - ACI 318: 26.13.3.3(b)  
   - CBC: 1908.9

9. Inspection of prestressed concrete:

a. Application of prestressing forces.  
   - ACI 318: 26.13.3.2(b)

b. Grouting of bonded prestressing tendons.  
   - ACI 318: 26.13.3.2(b)

    - ACI 318: 26.13.3.3(d)

11. Verification of in-place concrete strength before stressing post-tensioned reinforcement, and before removal of shores and forms from beams and structural slabs.  
    - ACI 318: 26.13.3.3(e)

12. Inspect formwork for shape, location, and dimensions of the concrete member being formed.  
    - ACI 318: 26.10.2

Notes:
(1) The "●" represents a required inspection activity for the project where it occurs.
**APPENDIX B**

**ARCHITECTURAL, PLUMBING, MECHANICAL, AND ELECTRICAL COMPONENTS
SPECIAL INSPECTION SCHEDULE**

<table>
<thead>
<tr>
<th>Verification and Inspection</th>
<th>Reference Standard</th>
<th>Frequency of Inspection&lt;sup&gt;(1)&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>IBC 2015</strong></td>
<td>Continuous Periodic</td>
</tr>
<tr>
<td>1. Architectural components:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Cladding - exterior, weighing more than 5 psf: erection and fastening.</td>
<td>IBC: 1705.12.5</td>
<td>●</td>
</tr>
<tr>
<td>b. Exterior insulation and finish system (EIFS):</td>
<td>IBC: 1705.16</td>
<td>●</td>
</tr>
<tr>
<td>d. Non-bearing walls – interior, weighing more than 15 psf.</td>
<td>IBC: 1705.12.5</td>
<td>●</td>
</tr>
<tr>
<td>e. Veneer, exterior and interior, weighing more than 5 psf: erection and fastening.</td>
<td>IBC: 1705.12.5</td>
<td>●</td>
</tr>
<tr>
<td>f. Access floors: erection and anchorage.</td>
<td>IBC: 1705.12.5.1</td>
<td>●</td>
</tr>
<tr>
<td>g. Suspended ceiling system: anchorage.</td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>h. Storage racks – 8 feet or greater in height: erection and anchorage.</td>
<td>IBC: 1705.12.7</td>
<td>●</td>
</tr>
<tr>
<td>2. Plumbing, mechanical, and electrical components:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Anchorage of electrical equipment for emergency and standby power systems.</td>
<td>IBC: 1705.12.6.1</td>
<td>●</td>
</tr>
<tr>
<td>b. Anchorage of other electrical and mechanical equipment over 400 lb. on floors or roofs.</td>
<td>IBC: 1705.12.6.2</td>
<td>●</td>
</tr>
<tr>
<td>c. Installation and anchorage of pipelines carrying hazardous chemicals and their associated mechanical units.</td>
<td>IBC: 1705.12.6.3</td>
<td>●</td>
</tr>
<tr>
<td>d. Installation and anchorage of pipelines greater than 8 inches in diameter.</td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>e. Installation and anchorage of ductwork designed to carry hazardous materials.</td>
<td>IBC: 1705.12.6.4</td>
<td>●</td>
</tr>
<tr>
<td>f. Installation and anchorage of ductwork greater than 6sf in cross section.</td>
<td></td>
<td>●</td>
</tr>
</tbody>
</table>
   
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Sprayed fire-resistant coatings.</td>
<td>IBC: 1705.14</td>
</tr>
<tr>
<td>b. Mastic and intumescent coatings.</td>
<td>IBC: 1705.15</td>
</tr>
<tr>
<td>c. Penetration firestops.</td>
<td>IBC: 1705.17, 1705.17.1</td>
</tr>
<tr>
<td>d. Fire-resistant joint systems.</td>
<td>IBC: 1705.17, 1705.17.2</td>
</tr>
</tbody>
</table>

4. Smoke control systems. | IBC: 1705.18 |

Notes:
(1) The "●" represents a required inspection activity for the project where it occurs.
**APPENDIX C**

**SOILS VERIFICATION AND SPECIAL INSPECTION SCHEDULE**

<table>
<thead>
<tr>
<th>Verification and Inspection</th>
<th>Reference Standard</th>
<th>Frequency of Inspection(^{(1)}) (During Task Listed)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CBC 2019</td>
<td>Continuous</td>
</tr>
<tr>
<td>1.  Verify materials below shallow foundations are adequate to achieve the design bearing capacity.</td>
<td>CBC: T-1705.6</td>
<td></td>
</tr>
<tr>
<td>2.  Verify excavations are extended to proper depth and have reached proper material.</td>
<td>CBC: T-1705.6</td>
<td></td>
</tr>
<tr>
<td>3.  Perform classification and testing of fill and backfill materials.</td>
<td>CBC: T-1705.6</td>
<td></td>
</tr>
<tr>
<td>4.  Verify use of proper materials, densities, and lift thicknesses during placement and compaction of fill and backfill.</td>
<td>CBC: T-1705.6</td>
<td>●</td>
</tr>
<tr>
<td>5.  Prior to placement of fill, observe subgrade and verify that site has been prepared properly.</td>
<td>CBC: T-1705.6</td>
<td>●</td>
</tr>
</tbody>
</table>

**Notes:**

(1) The "●" represents a required inspection activity for the project where it occurs.
SECTION 01500
TEMPORARY FACILITIES AND CONTROLS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Furnishing, maintaining, and removing construction facilities and temporary controls, including temporary utilities, construction aids, barriers and enclosures, security, access roads, temporary controls, and removal after construction.

1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. 306 Cold Weather Concreting.

B. OSHA - Occupational Safety and Health Act.

1.03 SUBMITTALS

A. General: For products specified to be furnished under this Section, submit product data in accordance to General Conditions, Section F, Labor and Construction.

1.04 TEMPORARY UTILITIES

A. Temporary Electrical Power: Contractor to arrange with the Inspector and MVRWRF Plant personnel regarding the power supply connection. The Contractor shall provide all the necessary electrical accessories, equipment, and materials for the connection including cables, power poles, transformer, switches, etc.

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

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

D. Temporary Water:
   1. Pay for and construct facilities necessary to furnish potable water for human consumption and non-potable water for use during construction.
   2. Remove temporary piping and connections and restore affected portions of the facility to original condition before final acceptance.
   3. District will provide water for 7-day final test.
   4. Development of Potable Water Supply:
      a. Potable water, except as outlined in the Special Conditions, is not available at construction site.
      b. Provide potable water for human consumption during construction period.
      c. Furnish potable water that meets requirements of Laws and Regulations.
   5. Development of Non-potable (Reclaimed, Title 22) Water Supply:
      a. Non-potable water is available within plant without cost. When combined demand of the Work and plant exceeds plant supply capacity, provide additional temporary supply capacity.
      b. Post sufficient number of signs throughout the Work area that warn the plant water is not potable.

E. Temporary Sanitary Facilities:
   1. Provide suitable and adequate sanitary facilities that are in compliance with applicable Laws and Regulations.
   2. At completion of the Work, remove sanitary facilities and leave site in neat and sanitary condition.
   3. Do not use District’s on-site sanitary facilities.

F. Temporary Fire Protection: Provide sufficient number of fire extinguishers of type and capacity required to protect the Work and ancillary facilities. Provide additional fire protection systems as required by the Fire Department.

G. First Aid: Post first aid facilities and information posters conforming to requirements of OSHA and other applicable Laws and Regulations in readily accessible locations.
   a. Section 01140 - Work Restrictions.

1.05 CONSTRUCTION AIDS

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

B. Use construction hoists, elevators, scaffolds, stages, shoring, and similar temporary facilities of ample size and capacity to adequately support and move loads.
C. Design temporary supports with adequate safety factor to assure adequate load bearing capability:
   1. When requested, submit design calculations by professional registered engineer prior to application of loads.
   2. Submitted design calculations are for information and record purposes only.

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

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

F. Warning Devices and Barricades: Adequately identify and guard hazardous areas and conditions by visual warning devices and, where necessary, physical barriers.
   1. Devices shall conform to minimum requirements of OSHA and State agency that administers OSHA regulations where Project is located.

G. Hazards in Public Right-of-Way:
   1. Mark at reasonable intervals, trenches and other continuous excavations in public right-of-way, running parallel to general flow of traffic, with traffic cones, barricades, or other suitable visual markers during daylight hours.
      a. During hours of darkness, provide markers with torches, flashers, or other adequate lights.
   2. At intersections or for pits and similar excavations, where traffic may reasonably be expected to approach head on, protect excavations by continuous barricades.
      a. During hours of darkness, provide warning lights at close intervals.
   3. Develop and file traffic control plans and obtain and follow permits required by jurisdictional agencies for work in public right-of-way.

H. Hazards in Protected Areas: Mark or guard excavations in areas from which public is excluded, in manner appropriate for hazard.
I. Above Grade Protection: On multi-level structures, provide safety protection that meets requirements of OSHA and State agency that administers OSHA regulations where Project is located.

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

K. Fences:
   1. Enclose temporary offices and storage areas with fence adequate to protect temporary facilities against acts of theft, violence, and vandalism.
   2. Protect temporary and permanent openings and close openings in existing fences to prevent intrusion by unauthorized persons. Bear responsibility for protection of plant and material on-site of the work when openings in existing fences are not closed.
   3. During night hours, weekends, holidays, and other times when no work is performed at site, provide temporary closures or enlist services of security guards to protect temporary openings.
   4. Fence temporary openings when openings are no longer necessary.

1.06 SECURITY

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

1.07 ACCESS ROADS

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

B. On-site Access Roads:
   1. Maintain access roads to storage areas and other areas to which frequent access is required.
   2. Maintain similar roads to existing facilities on-site of the Work to provide access for maintenance and operation.
   3. Protect buried vulnerable utilities under temporary roads with steel plates, wood planking, or bridges.
   4. Maintain on-site access roads free of mud. Under no circumstances shall vehicles leaving the site track mud off the site onto the public right-of-way.
1.08 TEMPORARY CONTROLS

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

B. Noise Control:
   1. In inhabited areas, particularly residential, perform operations in manner to minimize noise and comply with noise ordinances.
   2. In residential areas, take special measures to suppress noise during night hours.

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

1.09 REMOVAL

A. Remove temporary buildings and furnishings before inspection for Final Completion or when directed.

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

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

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

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION
SECTION 01600

PRODUCT REQUIREMENTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Product requirements, product selection; product options and substitutions; quality assurance; delivery, handling, and storage; and manufacturer’s instructions.

1.02 REFERENCES

A. American National Standards Institute (ANSI).


1.03 DEFINITIONS

A. Products: Inclusive of raw materials, finished goods, equipment, systems, and shop fabrications.

B. Special tools: Tools that have been specifically made for use on a product for assembly, disassembly, repair, or maintenance.

1.04 SUBMITTALS

A. As specified in General Conditions.

B. Calculations/certifications in accordance with NSF 61 and NSF 372 for materials in contact with drinking water.

1.05 GENERAL REQUIREMENTS

A. Comply with Specifications and referenced standards as minimum requirements.

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

C. Provide identical products when products are required in quantity.

D. Provide products with interchangeable parts whenever possible.

E. Require each equipment manufacturer to have maintenance facilities meeting the following requirements:
   1. Minimum 3 years operational experience.
2. Location in continental United States.
3. Equipment and tools capable of making repairs.
4. Staff qualified to make repairs.
5. Inventory of maintenance spare parts.

1.06 QUALITY ASSURANCE

A. Employ entities that meet or exceed specified qualifications to execute the Work.

B. Inspect conditions before executing subsequent portions of the Work. Accept responsibility for correcting unsatisfactory conditions upon executing subsequent portions of the Work.

C. Secure products in place with positive anchorage devices designed and sized to withstand stresses, vibration, and racking.

1.07 DELIVERY, HANDLING, STORAGE, AND PROTECTION

A. Prepare products for shipment by:
   1. Applying grease and lubricating oil to bearings and similar items.
   2. Separately packing or otherwise suitably protecting bearings.
   3. Tagging or marking products to agree with delivery schedule or shop drawings.
   4. Including complete packing lists and bills of material with each shipment.
   5. Packaging products to facilitate handling and protection against damage during transit, handling, and storage.

B. Transport products by methods that avoid product damage. Deliver products in undamaged condition in manufacturer's unopened containers or packaging.

C. Provide equipment and personnel to handle products by methods to prevent soiling or damage.

D. Upon delivery, promptly inspect shipments.
   1. Verify compliance with Contract Documents, correct quantities, and undamaged condition of products.
   2. Immediately store and protect products and materials until installed in Work.

E. Furnish covered, weather-protected storage structures providing a clean, dry, noncorrosive environment for all mechanical equipment, valves, architectural items, electrical and instrumentation equipment and special equipment to be incorporated into this project.
   1. Storage of equipment shall be in strict accordance with the “instructions for storage” of each equipment supplier and manufacturer including connection of heaters, placing of storage lubricants in equipment, etc.
   2. The Contractor shall furnish a copy of the manufacturer’s instructions for storage to the Engineer prior to storage of all equipment and materials.
3. Corroded, damaged, or deteriorated equipment and parts shall be replaced before acceptance of the project.
4. Equipment and materials not properly stored will not be included in an application for payment.

F. Store products with seals and legible labels intact.

G. Store moisture sensitive products in weathertight enclosures.

H. Maintain products within temperature and humidity ranges required or recommended by manufacturer.

I. Maintain storage areas at ambient temperatures recommended by manufacturer.

J. Protect painted surfaces against impact, abrasion, discoloration, and other damage. Repaint damaged painted surfaces.

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

L. Protect heat sensitive and UV sensitive products form damage due to heat and UV.

M. Store loose granular materials on solid surfaces in well-drained area. Prevent materials mixing with foreign matter.

N. Provide access for inspection.

O. Maintain equipment per the manufacturer’s recommendation and industry standards, including oil changes, rotation, etc. Provide a log of equipment maintenance to the Engineer on a monthly basis.
   1. Rotation log shall include, as a minimum, the equipment identification, date stored, date removed from storage, copy of manufacturer’s recommended storage guidelines, date of rotation of equipment, and signature of party performing rotation.

P. Protection after installation:
   1. Provide substantial coverings as necessary to protect installed products from damage from traffic and subsequent construction operations. Remove covering when no longer needed.
1.08 MANUFACTURER’S INSTRUCTIONS

A. Deliver, handle, store, install, erect, or apply products in accordance with manufacturer’s instructions, Contract Documents, and industry standards.
   1. Periodically inspect to assure products are undamaged and maintained under required conditions.

PART 2 PRODUCTS

2.01 PRODUCT SELECTION

A. When products are specified by standard or specification designations of technical societies, organizations, or associations only, provide products that meet or exceed reference standard and Specifications.

B. When products are specified with names of manufacturers but no model numbers or catalog designations, provide:
   1. Products by one of named manufacturers that meet or exceed Specifications.
   2. Accepted, or Equal.

C. When products are specified with names of manufacturers and model numbers or catalog designations, provide:
   1. Products with model numbers or catalog designations by one of named manufacturers.
   2. Accepted, or Equal.

D. When products are specified with names of manufacturers, but with brand or trade names, model numbers, or catalog designations by one manufacturer only, provide:
   1. Products specified by brand or trade name, model number, or catalog designation.
   2. Products by one of named manufacturers proven in accordance with requirements for or equals to meet or exceed quality, appearance and performance of specified brand or trade name, model number, or catalog designation.
   3. Accepted, or Equal.

E. When Products are specified with only one manufacturer followed by "or Equal," provide:
   1. Products meeting or exceeding Specifications by specified manufacturer.
   2. Accepted, or Equal.

2.02 PRODUCT OPTIONS AND SUBSTITUTIONS

A. General: Whenever a product is specified using a name of a particular manufacturer or supplier, the specific item cited shall be understood as establishing type, function, dimension, appearance, and quality desired. Other manufacturer’s
products will be considered for acceptance provided sufficient information is submitted to the Engineer for review to determine that the products proposed are equivalent to those named.

2.03 SPARE PARTS, MAINTENANCE PRODUCTS, AND SPECIAL TOOLS

A. Provide spare parts, maintenance products, and special tools as required by Specifications.

B. Box, tag, and clearly mark items.

C. Store spare parts, maintenance products, and special tools in enclosed, weather-proof, and lighted facility during the construction period.
   1. Contractor is responsible for spare parts and special tools until acceptance by District.
   2. Protect parts subject to deterioration, such as ferrous metal items and electrical components with appropriate lubricants, desiccants, or hermetic sealing.

2.04 SPARE PARTS AND SPECIAL TOOLS

A. Spare parts and special tools inventory list, see Appendix A:
   1. Equipment tag number.
   2. Equipment manufacturer.
   3. Subassembly component, if appropriate.
   4. Quantity.
   5. Storage location.

B. Large items:
   1. Weight: Greater than 50 pounds.
   2. Size: Greater than 24 inches wide by 18 inches high by 36 inches long.
   3. Stored individually.
   4. Clearly labeled:
      a. Equipment tag number.
      b. Equipment manufacturer.
      c. Subassembly component, if appropriate.

C. Smaller items:
   1. Weight: Less than 50 pounds.
   2. Size: Less than 24 inches wide by 18 inches high by 36 inches long.
   3. Stored in spare parts box.
   4. Clearly labeled:
      a. Equipment tag number.
      b. Equipment manufacturer.
      c. Subassembly component, if appropriate.
D. Spare parts and special tools box:
   1. Wooden box:
      a. Size: 24 inches wide by 18 inches high by 36 inches long.
   2. Hinged wooden cover
      a. Strap type hinges.
      b. Locking hasp.
      c. Spare parts inventory list taped to underside of cover.
   3. Coating: As specified in Section 09960 - High-Performance Coatings.
   4. Clearly labeled:
      a. The words “Spare Parts and/or Special Tools.”
      b. Equipment tag number.
      c. Equipment manufacturer.

PART 3 EXECUTION

3.01 CLOSEOUT ACTIVITIES

A. District may request advanced delivery of spare parts and special tools.
   1. Deduct the delivered items from inventory and provide transmittal documentation.

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

3.02 ATTACHMENTS

A. Appendix A - Spare Parts and Special Tools Inventory List.

END OF SECTION
APPENDIX A

SPARE PARTS AND SPECIAL TOOLS INVENTORY LIST
# MORENO VALLEY RWRF TERTIARY EFFLUENT EQUALIZATION PROJECT
## SPARE PARTS LIST

<table>
<thead>
<tr>
<th>Spec Section</th>
<th>Spec Heading</th>
<th>Equipment Tag</th>
<th>Quantity</th>
<th>Units</th>
<th>Description of Items</th>
<th>Turnover Date (Contractor to Engineer)</th>
<th>Turnover Date (Engineer to Operations)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Date</td>
<td>Contractor Initials</td>
</tr>
</tbody>
</table>

April 2020

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10546B10
SECTION 01610
PROJECT DESIGN CRITERIA

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Project design criteria such as temperature and site elevation.

1.02 PROJECT DESIGN CRITERIA

A. All equipment and materials for the project are to be suitable for performance in wastewater treatment plant environment and under following conditions:
   1. Design temperatures are:
      a. Outdoor temperatures: -7 to 45 degrees Celsius.
   2. Design groundwater elevation: 1,447.
   3. Freeze-thaw conditions.
   4. Moisture conditions: Defined in individual equipment sections.
   5. Site elevation: Approximately 1,470 feet above mean sea level.
   6. Wind blown dust.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION
SECTION 01612
SEISMIC DESIGN CRITERIA

PART 1   GENERAL

1.01  SUMMARY

A. Section includes: Seismic design criteria for the following:
   1. Anchorage of mechanical and electrical equipment.
   2. Seismic design and design of anchorage for small tanks fabricated off site and
      shipped to the Project site.
   3. Other structures or items as specified or indicated on the Drawings.

1.02  REFERENCES

A. American Society of Civil Engineers (ASCE):

1.03  SYSTEM DESCRIPTION

A. Design requirements:
   1. Design in accordance with the requirements of the building code as specified
      in Section 01410 - Regulatory Requirements:
      a. Design spectral acceleration at short period, $S_{DS}$: 1.00g.
      b. Component amplification factor, $a_p$: In accordance with ASCE 7-10,
         Tables 13.5-1 and 13.6-1.
      c. Component response modification factor, $R_p$: In accordance with
         ASCE 7-10, Tables 13.5-1 and 13.6-1.
      d. Component importance factor, $I_p$: 1.00.
   2. Do not use friction to resist sliding due to seismic forces.
   3. Do not use more than 60 percent of the weight of the mechanical and
      electrical equipment for designing anchors for resisting overturning due to
      seismic forces.
   4. Do not use more than 60 percent of the weight of the tank for resisting
      overturning due to seismic forces.
   5. Use anchor bolts, bolts, or welded studs for anchors for resisting seismic
      forces. Anchor bolts used to resist seismic forces shall have a standard hex
      bolt head embedded in the concrete. Do not use anchor bolts fabricated from
      rod stock with an L or J-shape.
   6. Do not use chemical anchors, concrete anchors, flush shells, powder actuated
      fasteners, sleeve anchors, or other types of anchors unless indicated on the
      Drawings or accepted in writing by the Engineer.
7. Seismic forces must be resisted by direct bearing on the fasteners used to resist seismic forces. Do not use connections that use friction to resist seismic forces.

1.04 SUBMITTALS

A. Shop drawings and calculations: Complete shop drawings and seismic calculations.

B. Calculations shall be signed and stamped by a civil or structural engineer licensed in the state where the Project is located.

PART 2 PRODUCTS
Not Used.

PART 3 EXECUTION
Not Used.

END OF SECTION
SECTION 01722
FIELD ENGINEERING

PART 1 GENERAL

1.01 SUMMARY
A. Section includes: Field engineering to establish lines and grades for the Work. Field engineering is responsibility of contractor.

1.02 SUBMITTALS
A. Submit as specified in General Conditions.
B. Pre-Excavation Report.

1.03 QUALITY ASSURANCE
A. Qualifications of surveyor or Engineer: Civil Engineer or Land Surveyor licensed in the state of California.
B. Accuracy of stakes, alignments, and grades may be checked randomly by Engineer:
   1. Notice of when checking will be conducted will be given.
   2. When notice of checking is given, postpone parts of the Work affected by stakes, alignments, or grades to be checked until checked.
   3. Do not assume that Engineer's check substitutes or complements required field quality control procedures.

1.04 CONSTRUCTION STAKES, LINES, AND GRADES
A. Execute the Work in accordance with the lines and grades indicated.
B. Make distances and measurements on horizontal planes, except elevations and structural dimensions.

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

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

1.06 SURVEY REFERENCE POINTS

A. Basic reference line, a beginning point on basic reference line, and a benchmark will be provided by District.

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

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

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

1.07 PROJECT SURVEY REQUIREMENTS

A. Establish minimum of 2 permanent benchmarks on site referenced to data established by survey control points.

B. Record permanent benchmark locations with horizontal and vertical data on Project Record Documents.

C. Assume responsibility for accuracy of stakes, alignments, and grades by performing verifications and checking in accordance with standard surveying practice.

D. Assume responsibility and cost for replacing lost or damaged stakes.

1.08 RECORD DOCUMENTS

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

B. Maintain complete, accurate log of control points and survey.
C. Affix civil engineer's or land surveyor's signature and registration number to record drawing to certify accuracy of information shown.

PART 2  PRODUCTS
Not Used.

PART 3  EXECUTION
Not Used.

END OF SECTION
SECTION 01738
SELECTIVE ALTERATIONS AND DEMOLITION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Cutting or modifying of existing and new work.
   2. Partial demolition of structures.

1.02 REFERENCES

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

B. International Concrete Repair Institute (ICRI):
   1. Guideline No. 310.2R - Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays, and Concrete Repair.

1.03 DEFINITIONS

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

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

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

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

1.04 DESCRIPTION OF WORK

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

1.05 SUBMITTALS

A. General:
   1. Submit specified in General Conditions.

B. Shop drawings: include:
   1. Demolition methods of load bearing structures not indicated on the Drawings; signed and sealed by structural Professional Engineer registered in state where Project is located.
   2. Method of removing embedded relics and antiques.

C. Submittals for information only:
   1. Permits and notices authorizing demolition.
   2. Certificates of severance of utility services.
   3. Permit for transport and disposal of debris.
   4. Demolition procedures and operational sequence.

D. Project record documents: Include locations of service lines and capped utilities.

1.06 QUALITY ASSURANCE

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

1.07 REGULATORY REQUIREMENTS

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

B. Comply with applicable air pollution control regulations.

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

A. Do not interfere with use of adjacent buildings, structures, or processes. Maintain free and safe passage to and from.

B. Prevent movement, settlement, or collapse of structures adjacent services, sidewalks, driveways, and trees. Provide and place bracing or shoring. Assume liability for movement, settlement, or collapse. Promptly repair damage.

C. Cease operations and notify Engineer immediately when safety of structure appears to be endangered. Take precautions to properly support structure. Do not resume operations until safety is restored.

D. Provide erect and maintain barricades, lighting, guardrails, and protective devices as required to protect building occupants, general public, workers, and adjoining property.

1.09 EXISTING SERVICES

A. Arrange and pay for capping and plugging utility services. Disconnect and stub off. Notify affected utility company in advance and obtain approval before starting demolition.

B. Place markers to indicate location of disconnected services.

1.10 MAINTAINING TRAFFIC

A. Do not close or obstruct roadways without permits.

B. Conduct operations with minimum interference to public or private roadways.

1.11 MATERIALS

A. Materials and equipment to be retained by District:
   1. Embedded relics and antiques such as cornerstones, cornerstone contents, commemorative plaques, and tablets.

B. Contractor shall furnish all materials, tools, equipment, devices, appurtenances, facilities, and services required for performing selective demolition work.

C. Erect weatherproof closures for exterior openings. Maintain exit requirements.

D. Erect and maintain dustproof partitions as required to prevent spread of dust, fumes, and smoke to other parts of building. On completion, remove partitions and repair damaged surfaces to match adjacent surfaces.

E. Protect interior of building from rain and water damage.
F. Provide and maintain protective devices to prevent injury from falling objects.

G. Locate guardrails in stairwells and around open shafts to protect workers. Post clearly visible warning signs.

H. Cause as little inconvenience to adjacent occupied building areas as possible.

I. Protect landscaping, benchmarks, and existing construction to remain from damage or displacement.

1.12 DEMOLITION

A. Demolish designated portions of structures and appurtenances in orderly and careful manner and in a sequence that provides for safe use of the site.

B. Assume possession of demolished materials, unless specified otherwise. Remove demolished materials from site at least weekly.

C. Prevent airborne dust. Use water or dust palliative when necessary. Provide and maintain hoses and connections to water main or hydrant.

D. Do not burn materials on site.

E. Immediately upon discovery, remove and dispose of contaminated, vermin-infested, or dangerous materials by safe means so as not to endanger health of workers and public.

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

1.13 REPAIR

A. Repair damage caused by demolition.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION
PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Requirements for each Commissioning phase of, the Project equipment/system and/or facility.

1.02 DEFINITIONS

A. Clean Water Facility Testing - Testing of complete facility utilizing clean water for purposes of confirming extended equipment/system operation prior to Process Start-up Phase.

B. Commissioning - The process of planning, testing, and process start-up of the installation for compliance with contract requirements and demonstrating, through documented verification, that the project has successfully met the Contractual requirements. It includes training the District's staff to operate the facility.

C. Commissioning Phases - The work activities of facility commissioning are grouped into the phases defined in the table below.

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</tbody>
</table>

D. Component - A basic building block of equipment, subsystems, and systems that requires installation or functional testing but does not have an electrical connection or internal electronics. (Examples: filter effluent piping and manual isolation valves).
E. Device - A basic building block of equipment, subsystems, and systems that requires installation or functional testing and does have an electrical connection or internal electronics. (Examples: filter level transmitter or water pump pressure transmitter).

F. Equipment - An assembly of component(s) and devices(s) that requires installation or functional testing. (Examples: Pump, motor, VFD, Ozone Generator, UV Disinfection System, etc.).

G. Facility - A grouping of process areas, systems, subsystems, equipment, components, and devices (Examples: treatment plant, pump station, etc.).

H. Functional Testing - Testing performed on a completed subsystem to demonstrate that equipment/system meets manufacturers’ calibration and adjustment requirements and other requirements as specified. Functional testing includes operating equipment/system manually in local, manually in remote (or remote manual), and automatically in remote (in remote auto).

I. Installation Testing - Testing to demonstrate that subsystem component (piping, power, networks, devices, etc.) is ready and meets the project requirements in advance of functional testing. Installation testing also includes manufacturers’ certification of installation and other requirements as specified to prepare equipment/system for Functional Testing. Also referred to as Field Acceptance Testing.

J. Manufacturer’s Certificate of Source Testing - When applicable, the form is used during Source Testing for the manufacturer to confirm that the applicable source tests have been performed and results conform to the Contract Documents. The form is provided at the end of this Section.

K. Manufacturer’s Certificate of Installation and Functionality Compliance - The form is used during Installation Testing and Functional Testing. It is submitted at the end of Functional Testing to confirm that the equipment/system is installed in conformance with the Contract Documents and that it meets the Functional Testing requirements defined in the Contract Documents. The form is provided at the end of this Section.

L. Process Area - A grouping of systems, subsystems, equipment, components, and devices that divide a facility into functional areas. (Examples: Filter Process Area or Chemical Area).

M. Process Operational Period - A period of time after completion of the process start-up set aside for final Operational Testing to verify facility performance meets the Contract Document requirements. This period may specifically limit other construction activities.

N. Process Start-up Phase - Operating the facility to verify performance meets the Contract Document requirements.
O. Process Start-Up - Activities conducted after the testing and training phase that are necessary to place systems or process areas into operational service.

P. Product - A system, subsystem or component.

Q. Subsystem - A building block of systems made up from a grouping of components, devices, and equipment that perform a definable function. (Examples: Filter No. 1 Backwash Subsystem, Sedimentation Basin No. 1 Hoseless Sludge Removal Subsystem).

R. System - A grouping of subsystems, equipment, components, and devices that perform a definable function. (Examples: Filter No. 1, Sedimentation Basin).

1.03 COMMISSIONING COORDINATOR (CC)

A. Designate and provide a CC for this project.

B. Submit summary of the CC’s qualifications within 30 days of NTP:
   1. Include description of previous experience as a CC on similar projects for the designated CC with a list of references including phone numbers for review and District approval.

C. CC responsibilities include the following:
   1. Lead efforts relating to Commissioning.
   2. Be thoroughly familiar with commissioning requirements in the Contract Documents.
   3. Be regularly engaged and experienced in all aspects of commissioning.
   4. Provide technical instruction for commissioning.
   5. Provide primary interface with Engineer and District for efforts relating to Commissioning of Project facilities.
   6. Coordinate training efforts.

1.04 SERVICES OF MANUFACTURER’S REPRESENTATIVES

A. Qualification of manufacturer’s representative as specified in the Contract Documents technical sections include the following:
   1. Authorized representative of the manufacturer, factory trained and experienced in the technical applications, installation, operation, and maintenance of respective equipment/system with full authority by the equipment/system manufacturer to issue the certifications required of the manufacturer.
   2. Competent, experienced technical representative of equipment/system manufacturer for assembly, installation, testing guidance, and training.
   3. Additional qualifications may be specified in the individual sections.
   4. Submit qualifications of the manufacturer’s representative no later than 30 days in advance of required observations.
   5. Representative subject to approval by District and Engineer.
6. No substitute representatives will be allowed until written approval by District and Engineer has been obtained.

B. Completion of manufacturer on-site services: Engineer approval required.

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

D. Manufacturer’s on-site services as specified in the Contract Documents include the following:
   2. Provide weekly copies of manufacturer's representatives field notes and data to Engineer.
   3. Other requirements as specified in the Contract Documents.

1.05 PLANNING PHASE

A. Overview of Planning Phase:
   1. Define approach and timing for Commissioning.

B. District training plan and schedule:
   1. Training outcomes:
      a. District’s operations, maintenance, and engineering staff have the information needed to safely operate, maintain, and repair the equipment/systems provided in the Contract Documents.
   2. Training objectives:
      a. To instruct personnel in the operation and maintenance of the equipment/system. Instruction shall include step-by-step troubleshooting procedures with all necessary test equipment/system.
      b. To instruct personnel in the removal, inspection, and cleaning of equipment/system as needed.
      c. Training tailored to the skills and job classifications of the staff attending the classes (e.g., plant superintendent, treatment plant operator, maintenance technician, electrician, etc.).
      d. Provide supporting documentation, such as vendor operation and maintenance manuals.
   3. Training schedule:
      a. Schedule District’s staff training within the constraints of their workloads. Those who will participate in this training have existing full-time work
assignments, and training is an additional assigned work task, therefore, scheduling is imperative. District staff work schedules regularly shift, as treatment facilities are typically operated on an around-the-clock basis.

4. Training plan:
   a. Coordinate and arrange for manufacturer’s representatives to provide both classroom-based learning and field (hands-on) training, based on training module content and stated learning objectives.
   b. Conduct classroom training at location designated by District.
   c. Scope and sequence:
      1) Plan and schedule training in the correct sequence to provide prerequisite knowledge and skills to trainees.
         a) Describe recommended procedures to check/test equipment/system following a corrective maintenance repair.

5. Training scheduling coordination:
   a. CC is responsible for the following:
      1) Coordinate schedule for training periods with the District’s personnel and manufacturer's representatives (instructors).
   b. Complete District training no sooner than 15 calendar days prior to start of process start-up of each system.

6. Meetings:
   a. CC is responsible for setting commissioning coordination meeting dates and times, as well as preparing the agendas and meeting minutes.
   b. CC shall meet with Engineer and District’s designated training coordinator to develop list of personnel to be trained and to establish expected training outcomes and objectives at least 60 calendar days prior to commissioning of equipment/system.
   c. CC shall conduct commissioning progress meetings throughout construction, to plan, scope, coordinate, and schedule future activities, resolve problems, etc.
      1) Frequency: Monthly minimum. Increase frequency as needed based on complexity and quantity of commissioning activities.

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

8. Training sessions:
   a. Provide training sessions for equipment/system as specified in the individual equipment/system section.

C. Commissioning Schedule:
1. Commissioning overview:
   a. Comply with Commissioning Roles and Responsibilities Matrix specified at the end of this Section.

2. Submit due date:
   a. Submit Commissioning Schedule not less than 60 calendar days prior to planned initial commissioning of each subsystem or system.

3. Schedule requirements:
   a. Schedule durations and float for commissioning activities to ensure Work does not fall behind schedule due to complications or delays during commissioning.
   b. Time-scaled network diagram detailing the work to take place in the period between 90 calendar days prior to planned initial commissioning of equipment and systems, and prior to the date of Substantial Completion, together with supporting narrative.
   c. Provide detailed schedule of commissioning activities including durations and sequencing requirements.

1) Identify the following activities:
   a) Testing and Training Phase:
      (1) Source Testing.
      (2) District Training.
      (3) Installation Testing.
      (4) Functional Testing.
      (6) Closeout Documentation.
   b) Process Start-Up Phase:
      (1) Process Start-Up.
      (2) Process Operational Period.
   d. Schedule manufacturer’s services to avoid conflict with other on-site testing or other manufacturers’ on-site services.
   e. Verify that conditions necessary to allow successful testing have been met before scheduling services.

D. Subsystem testing plans:
1. Provide separate testing plans for each individual subsystem and system that include the following:
   a. Approach to testing including procedures, schedule, and recirculation requirements.
b. Test objective: Demonstrate subsystem meets the design requirements as specified in the technical sections.

c. Test descriptions, forms, temporary systems (pumps, piping, etc.), shutdown requirements for existing systems, test forms, test logs, witness forms, and checklists to be used to control and document the required tests.

d. Test forms: Include, but not limited to, the following information:
   1) Tag and name of equipment/system to be tested.
   2) Test date.
   3) Names of persons conducting the test.
   4) Names of persons witnessing the test, where applicable.
   5) Test data.
   6) Applicable project requirements.
   7) Check offs for each completed test or test step.
   8) Place for signature of person conducting tests and for the witnessing person, as applicable.

e. Define start-up sequencing of unit processes:
   1) Include testing of alarms, interlocks, permissives, control circuits, capacities, speeds, flows, pressures, vibrations, sound levels, and other parameters.
   2) Provide detailed test procedures setting forth step-by-step descriptions of the procedures for systematic testing of equipment/system.
   3) Demonstrate proper rotation, alignment, speed, flow, pressure, vibration, sound level, adjustments, and calibration.
      a) Perform initial checks in the presence of and with the assistance of the manufacturer’s representative.
   4) Demonstrate proper operation of each control loop function including mechanical, electrical, alarms, local and remote controls, instrumentation, and other equipment/system functions.
      a) Generate signals with test equipment/system to simulate operating conditions in each control mode.

2. Engineer approval of test plan is required prior to performing test.
   a. Revise and update test plans based on review comments, actual progress, or to accommodate changes in the sequence of activities.
   b. Submit test reports for each phase of testing for each equipment/system.
   c. Engineer approval of preceding test reports is required prior to start of next test.
   d. Tests will be rescheduled if test plan is not approved by required deadline.
      1) Contractor is responsible for any resulting delay.

3. Contractor is responsible to reproduce and distribute final test procedures.
   a. Provide 3 copies for Engineer.

4. Tests may commence only after Engineer has received approved test plan copies.
5. Submittals:
   a. Submit test plans not less than 15 calendar days prior to planned installation testing of subsystem or system.
   b. Completed Manufacturer’s Certificate of Installation and Functionality Compliance.
   c. Test procedures and forms: Provide signed-off copy of test forms and test reports upon completion of the test.
   d. Test reports:
      1) Submit preliminary copies within 1 day after testing completion.
      2) Submit final copies and report within 14 days of testing completion.

E. Clean Water Facility Testing Plan:
   1. Submit a Clean Water Facility Testing Plan equivalent to the requirements of the subsystem test plans a minimum of 30 calendar days prior to Clean Water Facility Testing.

1.06 TESTING AND TRAINING PHASE

A. Overview of Testing and Training Phase:
   1. General:
   2. Contractor responsibilities:
      a. Furnish labor, power, chemicals, tools, equipment, instruments, and services required for and incidental to completing commissioning activities in accordance with the approved Commissioning Plans.
      b. Prior to testing, verify equipment protective devices and safety devices have been installed, calibrated, and tested.
      c. Acceptable tests: Demonstrate the equipment/system performance meets the requirements stated in the Contract Documents.
         1) When the equipment/system fails to meet the specified requirements, perform additional, more detailed, testing to determine the cause, correct, repair, or replace the causative components and repeat the testing that revealed the deficiency.

B. Source testing:
   1. Also referred to as factory testing or factory acceptance testing (FAT).
   2. Test components, devices, and equipment/system for proper performance at point of manufacture or assembly as specified in the technical sections.
   3. Notify Engineer in writing when equipment/system is ready for source inspection and testing.
   4. Source Test Plan:
      a. As specified in this Section and other technical sections.
      b. Source testing requirements as specified in technical sections.
         1) Non-witnessed: Provide Manufacturer’s Certificate of Source Testing.
2) Witnessed: 1 District’s representative and 1 Engineer’s representative present during testing, unless otherwise specified, and provide Manufacturer’s Certificate of Source Testing.

c. Prepared by Contractor as a result of discussions and planning emerging from regularly conducted commissioning meetings for source tests as specified in Contract Documents.

d. Provide the following items for each Source Test:
   1) Purpose and goals of the test.
   2) Identification of each item of equipment/system, including system designation, location, tag number, control loop identifier, etc.
   3) Description of the pass/fail criteria that will be used.
   4) Listing of pertinent reference documents (Contract Documents and industry standards or sections applicable to the testing).
   5) Complete description, including drawings or photographs, of test stands and/or test apparatus.
   6) Credentials of test personnel.
   7) Descriptions of test equipment to be used, product information, and all appropriate calibration records for the test equipment.
   8) Test set-up procedures.
      a) Level of detail shall be sufficient for any witness with rudimentary technical aptitude to be able to follow the steps and develop confidence that tests were being performed as planned.
      b) All steps are significant and shall be included in the procedures.
   10) Sample data logs and data recording forms.
   11) Sample computations or analyses with the results in the same format as the final report to demonstrate how data collected will be used to generate final results.
      a) Complete disclosure of the calculation methodologies.
      b) Include a sample for each type of computation required for the test and analysis of the results.
   12) Detailed outline of the Source Test report.
   13) Sample test reports.

e. Submit Source Test Plan and forms as specified in the technical sections.
   1) Submit a copy of the Source Test Plan at least 21 days before any scheduled test date.
   2) Engineer approval of Source Test Plan required prior to beginning source testing.
   3) Schedule the testing after approval of the test procedures submittal.

f. Indicate the desired dates for source inspection and testing.
   1) Notify Engineer of scheduled tests a minimum of 15 days before test date.

5. Test results:
   a. Prepare and submit test results with collected data attached.
6. Contractor is responsible for costs associated with District’s representatives and Engineer’s representative witnessing Source Tests.
   a. Include costs for at least the following:
      1) Transportation:
         a) Travel 1 day on commercial airline to site including air flight costs and $1,600 allowance per person per day.
         b) Travel 1 day on commercial airline from site including air flight costs and $1,600 allowance per person per day.
         c) Rental car from hotel to and from the test site.
      2) Hotel costs at a facility with American Automobile Association 4-star rating or equivalent for single occupancy room per person per day.
      3) Meal allowance of $60 per person per day.
      4) On-site time: 1 day at the site, unless specified otherwise, including $1,600 allowance per person per day.
   b. If Source Test is not ready when witnesses arrive or if Source Test fails, the witnesses will return home with Contractor responsible for costs associated with the trip including costs described above. Contractor is responsible for rescheduling Source Test and witnesses’ costs associated with the second trip including costs described above.
   c. Contractor is responsible for witnesses’ costs associated with retests including costs described above.

7. Contractor is responsible for providing fuel, chemicals, and other consumables needed for Source Testing.

C. District training:
   1. Training instruction format:
      a. The training for operations and maintenance personnel shall be provided as one entity.
      b. Instructors shall apply adult education best practices, emphasizing learner participation and activity.
      c. Training delivery may include problem solving, question/answer, hands-on instruction, practice, evaluation/feedback tools, and lecture.
      d. Visual aids and hands-on practice sessions must support training objectives.
      e. Lecturing should be less than 30 percent of class time.
      f. Conduct hands-on instruction according to the following descriptions:
         1) Present hands-on demonstrations of at least the following tasks:
            a) Proper start-up, shutdown, and normal and alternative operating strategies.
            b) Common corrective maintenance repairs for each group.
            c) Describe recommended procedures to check/test equipment/system following a corrective maintenance repair.
2) Use tools and equipment provided by manufacturer to conduct the demonstrations.
   a) Submit requests for supplemental assistance and facilities with Contractor’s proposed lesson plans.
3) Contractor remains responsible for equipment disassembly or assembly during hands-on training situations involving equipment disassembly or assembly by District’s personnel.
   a) Provide written certification of proper equipment/system operation to Engineer after completion of hands-on training.

2. Class agenda:
   a. Include the following information in the agenda:
      1) Instructor name.
      2) Listing of subjects to be discussed.
      3) Time estimated for each subject.
      4) Allocation of time for District staff to ask questions and discuss the subject matter.
      5) List of documentation to be used or provided to support training.
   b. District may request that particular subjects be emphasized and the agenda be adjusted to accommodate these requests.
   c. Distribute copies of the agenda to each student at the beginning of each training class.

3. Number of students:
   a. Estimated maximum class size: 15 persons.
      1) District will determine the actual number of students.
      2) Engineer will provide an estimated headcount 1 week prior to the class, so that the instructor can provide the correct number of training aids for students.

4. Instructor qualifications:
   a. Provide instructors completely knowledgeable in the equipment/system for which they are training.
   b. Provide instructors experienced in conducting classes.
   c. Provide instructor’s technical preparation and instructional technology skills and experience.
   d. Sales representatives are not qualified instructors unless they possess the detailed operating and maintenance knowledge required for proper class instruction.
   e. If, in the opinion of the District, an appropriately knowledgeable person did not provide the scheduled training, such training shall be rescheduled and repeated with a suitable instructor.

5. Training aids:
   a. Instructors are encouraged to use audio-visual devices, P&IDs, models, charts, etc. to increase the transfer of knowledge.
   b. Instructors shall provide such equipment (televisions, video recorder/player, computer, projectors, screens, easels, etc.), models, charts, etc. for each class.
c. Instructor is responsible for confirming with Engineer and District in advance of each class that the classroom will be appropriate for the types of audiovisual equipment to be employed.

6. Classroom documentation:
   a. Trainees will keep training materials and documentation after the session.
   b. Operations and maintenance manuals, as specified in technical sections:
      1) Provide a minimum of 2 copies of final Engineer-approved operations and maintenance manuals as specified in Section E01430-Operation and Maintenance Data for use during the classroom instruction.
      2) District reserves the right to delay training for a particular equipment item if the operations and maintenance manuals for that equipment are incomplete, inaccurate, or otherwise unsuitable for use by the District’s staff.
      3) No contract extensions or extra costs will be allowed for training delays due to operations and maintenance manual submittal delays.
   c. Provide supplemental documentation handouts to support instruction.
   d. Digitally record audio and video of each training session.
      1) Include classroom and field instruction with question and answering periods.
      2) Engineer approval required for producer of video materials from one of the following options:
         a) Qualified, professional video production company.
         b) Contractor demonstrates satisfactory skill.
      3) Record in digital format and recording shall become property of the District.
         a) Provide audio quality that is not degraded during the recording of the field sessions due to background noise, space, distance or other factors.
      4) Video files shall be file format and delivery medium as directed and approved by District.
      5) Provide 2 complete sets of video materials fully indexed and cataloged with printed labels stating session content and dates recorded.
      6) The Contractor shall provide a written release from all claims to the recorded training material produced, if required.
   e. Training modules:
      1) Provide a training module for each equipment category.
      2) Divide each training module’s instructional content into discrete lesson plans.
   f. Lesson plans:
      1) Provide performance-based learning objectives.
      2) State learning objectives in terms of what the trainees will be able to do at the end of the lesson.
3) Define student conditions of performance and criteria for evaluating instructional success.

4) Instruction lesson plan outlines for each trade.
   a) Provide specific components and procedures.

5) Minimum requirements:
   a) Hands-on demonstrations planned for the instructions.
   b) Cross-reference training aids.
   c) Planned training strategies such as whiteboard work, instructor questions, and discussion points or other planned classroom or field strategies.
   d) Attach handouts cross-referenced by section or topic in the lesson plan.
   e) Indicate duration of outlined training segments.

6) Provide maintenance instruction lesson plans including mechanical, HVAC, instrumentation, and electrical aspects:
   a) Equipment operation:
      (1) Describe equipment’s operating (process) function and system theory.
      (2) Describe equipment’s fundamental operating principles and dynamics.
      (3) Identify equipment’s mechanical, electrical, and electronic components and features.
      (4) Identify support equipment associated with the operation of subject equipment.
      (5) Detail the relationship of each piece of equipment or component to the subsystems, systems, and process.
      (6) Cite hazards associated with the operations, exposure to chemicals associated with the component, or the waste stream handled by the component.
      (7) Specify appropriate safety precautions, equipment, and procedures to eliminate, reduce, or overcome hazards.
   b) Detailed component description:
      (1) Define Preventative Maintenance (PM) inspection procedures required on equipment in operation, spot potential trouble symptoms (anticipate breakdowns), and forecast maintenance requirements (predictive maintenance).
         (a) Review preventive maintenance frequency and task analysis table.
      (2) Identify each component function and describe in detail.
      (3) Where applicable, group relative components into subsystems.
      (4) Identify and describe in detail equipment safety features, permissive and controls interlocks.
7) Provide the following information in equipment troubleshooting lesson plans:
   a) Define recommended systematic troubleshooting procedures as they relate to specific craft problems.
   b) Provide component specific troubleshooting checklists as they relate to specific craft problems.

8) Provide the following information in equipment Corrective Maintenance (CM) troubleshooting lesson:
   a) Describe recommended equipment preparation requirements as they relate to specific craft problems.
   b) Identify and describe the use of any special tools required for maintenance of the equipment as they relate to specific craft problems.
   c) Describe component removal/installation and disassembly/assembly procedures for specific craft repairs.
   d) Perform at least 2 hands-on demonstrations of common corrective maintenance repairs.
      (1) Additional demonstrations may be required by the District.
   e) Describe recommended measuring instruments and procedures, and provide instruction on interpreting alignment measurements, as appropriate.

7. Class logistics:
   a. Delivery time minimum: 2 hours.
   b. Delivery time maximum: 4 hours.
      1) Longer time requires Engineer approval.
   c. Class agenda:
      1) Refreshment break: One 10-minute break.
      2) Meal break: One 45-minute break, unless otherwise specified.
      3) Schedule refreshment breaks and meal breaks to meet the class needs and District work rules.
   d. Schedule specific sessions:
      1) Minimum of 30 days in advance to allow District staffing arrangements to take place.
      2) At the times requested by the District, within the period 7 a.m. to 7 p.m. Monday through Friday.
         a) Times scheduled will be at District’s discretion.
      3) District approval and confirmation required for session schedules.
      4) Provide minimum of 2 sessions for each class unless otherwise noted.
         a) The purpose of having multiple sessions on each class is to accommodate the attendance of as many District personnel working different shifts as possible.

8. Distribute Training Evaluation Form following each training session.
   a. Training Evaluation Form is included in this Section.
b. Return completed Training Evaluation Forms to District’s designated training coordinator immediately after session is completed.

c. Revise training sessions judged “Unsatisfactory” by a majority of attendees.

1) Conduct training sessions again until a satisfactory rating is achieved at no additional cost to District.

9. Submittals:

a. Prior to the training session:

1) Instructor qualifications: Due 30 calendar days prior to initial training session.

2) Training course materials: Due 14 calendar days prior to initial training session.
   a) Training agenda, lesson plan, presentation, and handouts.
   b) Other audio-visual aids utilized during each training course.
   c) Format: 2 electronic copies and 3 hard copies organized in notebooks.

b. Post training session:

1) Training course materials: Due 14 calendar days after class completion.
   a) Video recordings.
   b) Class attendance sheet.
   c) Training agenda, final lesson plan, presentation, and handouts.
   d) Other audio-visual aids utilized during each training course.
   e) Provide materials for all sessions of the class in a single transmittal.
   f) Format: 2 electronic copies and 3 hard copies organized in notebooks.

D. Installation Testing:

1. Perform subsystem testing according to approved Subsystem Testing Plans.

2. Initiate the Manufacturer’s Certificate of Installation and Functionality Compliance for all equipment.
   a. Manufacturer’s Certificate of Installation and Functionality Compliance form is included in this Section.

   b. Manufacturer’s Certificate of Installation and Functionality Compliance certifies the equipment meets the following requirements:
      1) Has been properly installed, adjusted, aligned, and lubricated.
      2) Is free of any stresses imposed by connecting piping or anchor bolts.
      3) Is able to be operated as necessary for Functional Testing.

   c. Form shall be submitted after completion of Functional Testing, as specified in this Section.

3. Coordinate Installation Testing with restrictions and requirements as specified in Section 01140 - Work Restrictions.

4. Perform coating holiday testing as specified in Section 09960 – High-Performance Coatings.
5. Perform pressure and leakage testing as specified in individual component Sections and Section 15956 - Piping Systems Testing.

E. Functional Testing:
1. Perform subsystem testing according to approved Subsystem Testing Plan.
2. Notify the Engineer 5 days prior to when the Work is ready for Functional Testing.
   a. Perform testing in the presence of the Engineer.
3. Determine Functional Testing durations with District’s input.
   a. Durations will vary depending on the availability of water for testing.
   b. Target minimum Functional Test duration: 8 hours.
      1) Identify equipment/system that cannot be tested for a minimum of 8 hours as specified in technical sections.
4. Perform Functional Testing as specified in technical sections.
   a. Perform Functional Testing in addition to the other tests specified in the technical sections.
   b. Perform Functional Testing to demonstrate that the component equipment functions as an entire system in accordance with the design requirements.
   c. Perform Functional Testing to demonstrate that the unit process has operated in a manner necessary to demonstrate equipment/system functions manually in local, manually in remote (or remote manual), and automatically in remote (in remote auto).
   d. Perform testing with District-provided water.
   e. Repair or replace parts that operate improperly and retest.
   f. Submit testing results as specified in the technical sections to the District and Engineer for approval of Functional Testing results.
5. Provide completed Manufacturer’s Certificate of Installation and Functionality Compliance forms for all equipment.
   a. Manufacturer’s Certificate of Installation and Functionality Compliance form is included in this Section.
   b. Manufacturer’s Certificate of Installation and Functionality Compliance certifies the equipment/system meets the following requirements:
      1) Is suitable for satisfactory full-time operation under full-load conditions.
      2) Operates within the allowable limits for vibration and noise.
      3) Electrical and instrumentation requirements:
         a) Electrical equipment, instrumentation, and control panels are properly installed, calibrated, and functioning.
         b) Electrical Installation Testing is complete, and test results have been approved by Engineer.
            (1) Noted deficiencies have been corrected.
            (2) Relays, circuit breakers, and other protective devices are set.
c) Control logic for start-up, shutdown, sequencing, interlocks, control, and emergency shutdown has been tested and is properly functioning.
d) Motor control is calibrated and tested.

F. Clean Water Facility Testing:
   1. Utilize plant water.
   2. Do not begin Clean Water Facility Testing until Engineer has approved submittals for Functional Testing requirements.
   3. Test entire facility with recirculating water supply at design flow for the largest single process or system train to ensure proper complete facility (equipment/system) hydraulic performance.
   4. Perform testing in Engineer's presence unless such presence is expressly waived in writing.
   5. The purpose of Clean Water Facility Testing is to confirm extended equipment/system operation prior to process start-up.
      a. Testing shall occur for a minimum of 7 days with all systems operational to the extent possible.

G. Closeout documentation:
   1. Submittals:
      a. Provide records generated during Commissioning Phase of Project.
         1) Required documents include but are not limited to:
            a) Training documentation.
            b) Manufacturer’s Certificate of Source Testing.
            c) Manufacturer’s Certificate of Installation and Functionality Compliance.
            d) Daily logs of equipment/system testing identifying tests conducted and outcome.
            e) Test forms and documentation.
            f) Functional Testing results.
            g) Logs of time spent by manufacturer's representatives performing services on the job site.
            h) Equipment lubrication records.
            i) Electrical phase, voltage, and amperage measurements.
            j) Insulation resistance measurements.
            k) Bearing temperature measurements.
         2) Data sheets of control loop testing including testing and calibration of instrumentation devices and setpoints. Format: 2 electronic copies and 3 hard copies organized in notebooks.
         3) Due date: Within 14 calendar days of Substantial Completion.
1.07 PROCESS START-UP PHASE

A. Overview of Process Start-Up Phase:
   1. Operating facility to verify performance meets Contract Document requirements.

B. Process Start-Up:
   1. Perform process start-up in the presence of the Engineer.
   2. Pre-start-up activities:
      a. Commissioning Documentation and Data Review.
      b. Start-Up Go/No-Go Decision Criteria.
      c. Building and Fire Inspection Compliance Check.
      d. Process Start-Up Sequence Review.
         1) Submit a Process Start-Up plan for review by Engineer not less than 60 calendar days prior to planned commencement of process start-up activities.
         2) Include the following:
            a) Pre-start-up activities.
            b) Process Start-Up.
            c) Process Operational Period.
      e. Description of Temporary Testing Arrangement, if applicable.
      f. Final Process Start-Up Forms and Documentations.
      g. Final Operational Testing Plan.
   3. Control loop tuning.
      a. Perform control loop tuning during system testing with water to the extent possible.
      a. Process start-up individual process areas comprised of multiple interdependent systems where possible and beneficial to reduce complexity and risk of complete facility testing.
      b. Process area test flows may be limited by upstream and downstream process constraints (i.e., tank and basin volumes) and/or localized recirculation capabilities.
   5. Facility-wide process start-up.
      a. Upon approved completion of pre-start-up activities, perform entire facility process start-up.
         1) Complete control loop tuning during this phase of process start-up.
         2) Continue process start-up operations until facility meets or exceeds the Contract requirements.
      b. Process control systems testing:
         1) Test complete system instrumentation, controls and PLC, HMI, and LOI programming for the facility.
      c. HVAC systems start-up and testing:
         1) Test complete HVAC system for the facility.
d. Ancillary systems start-up and testing:
   1) Test complete security system, phone system, fire alarm system, etc.
      for the facility.

e. Remaining equipment/system tests:
   1) Conduct remaining specified equipment/system performance tests
      that could not be performed during the Testing and Training Phase
      due to inter-system and/or treatment process dependencies.

C. Process Operational Period:
   1. Prior to beginning the Process Operational Period:
      a. Conformance with treatment standards is required prior to Operational
         Testing, if applicable.
         1) Biological processes require time to build up the necessary population
            of organisms to meet treatment standards, as specified in Section
            01140 - Work Restrictions.
      b. Correct any outstanding punch list items prior to the Operational Testing.
   2. Duration: 7 calendar days.
   3. Engineer will be present for process operational period unless such presence
      is expressly waived in writing.
   5. Contractor to provide:
      a. Specified start-up materials and operating supplies.
      b. Necessary craft of labor assistance, in the event of an emergency
         equipment failure requiring immediate attention (emergency is defined as
         a failure of function which precludes further operation of a critical segment
         of or the whole of the Work) with a response time of no more than 4 hours
         from time of notification.
      c. Manufacturer’s authorized representative to supervise placing
         equipment/systems in operation and provide guidance during Operational
         Testing per applicable section.
      d. Necessary manufacturer’s representatives and operating supplies for
         retesting systems that fail to pass the initial Operational Testing due to
         deficiencies in products of workmanship at no additional cost to District.
      e. List of 24-hour “on-call” representative supervisory persons who will
         monitor Operational Testing and serve as liaison for Engineer and District.
   6. District will provide:
      a. Operations personnel for duration of test.
   7. Prior to date of Substantial Completion of Installation, the Contractor’s CC shall
      oversee Process Operational Period.
      a. District staff will operate the completed Project construction.
      b. Entire system shall continuously meet performance requirements and shall
         operate without fault, failure, or defect for a continuous period.
      c. Individual equipment/system failures that are corrected within 24 hours
         and do not prevent the entire project from continuously satisfying
established operational requirements shall not require the consecutive day test to be restarted unless the failure recurs.

d. Restart the consecutive test period for any of the following conditions:
   1) Any failure of complete Project construction to meet operational requirements.
   2) When malfunctions or deficiencies cause shutdown or partial facility operation, or results in failure of the complete Project construction to meet operational requirements.
   3) Any individual equipment/system failure that meets any of the following conditions:
      a) Requires more than 24 hours to correct, unless otherwise specified in Section 17950 - Testing, Calibration, and Commissioning.
      b) Recurs within the 24-hour correction period requiring further correction.
   4) Immediately correct defects in material, workmanship, or equipment/system which became evident during Operational Testing.

1.08 Instrumentation and Controls Fine-Tuning:

   A. After the Process Operational Period, test PCIS system for additional 20 days as specified in Section 17950 - Testing, Calibration, and Commissioning to identify issues and make corrections, as needed.

PART 2 PRODUCTS
Not Used

PART 3 EXECUTION
Not Used
MANUFACTURER’S CERTIFICATE OF SOURCE TESTING

OWNER ___________________________ EQPT/SYSTEM ___________________________
PROJECT NAME ____________________ EQPT TAG NO. ___________________________
PROJECT NO. ______________________ EQPT SERIAL NO. _______________________
SPECIFICATION NO. ________________ SPECIFICATION TITLE ___________________

Comments: ___________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

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

Date of Execution: _____________________________, 20_____

Manufacturer: ______________________________________

Manufacturer’s Authorized Representative Name (print): ___________________________

__________________________________________
(Authorized Signature)

If applicable, Witness Name (print): ___________________________

__________________________________________
(Witness Signature)
MANUFACTURER’S CERTIFICATE OF
INSTALLATION AND FUNCTIONALITY COMPLIANCE

OWNER _________________ EQPT/SYSTEM _______________________
PROJECT NAME ___________________ EQPT TAG NO. _______________________
PROJECT NO. ___________________ EQPT SERIAL NO. _______________________
SPECIFICATION NO. _______________
SPECIFICATION TITLE _______________________

I hereby certify the installation and function of the above-referenced equipment/system as defined in the Contract Documents. The above-referenced equipment/system has been: (Check Applicable)

☐ Installed in accordance with manufacturer’s recommendations.
☐ Inspected, checked, and adjusted.
☐ Serviced with proper initial lubricants.
☐ Electrical/instrumentation and mechanical connections meet quality and safety standards.
☐ All applicable safety equipment has been properly installed.
☐ Functionally tested.
☐ System has been performance tested, and meets or exceeds specified performance requirements.

NOTES:
Attach test results with collected data and test report.

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

Comments: _______________________

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

Date: _______________________

Manufacturer: _______________________

Manufacturer’s Authorized Representative Name (print): _______________________

By Manufacturer’s Authorized Representative: _______________________

(Authorized Signature)
# COMMISSIONING

## TRAINING EVALUATION FORM

<table>
<thead>
<tr>
<th>Equipment/System Item:</th>
<th>Vendor/Manufacturer:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date:</td>
<td>Name of Representative:</td>
</tr>
</tbody>
</table>

1. Was representative prepared? [Acceptable][Unacceptable][N/A]
2. Was an overview description presented? [Acceptable][Unacceptable][N/A]
3. Were specific details presented for system components? [Acceptable][Unacceptable][N/A]
4. Were alarm and shutdown conditions clearly presented? [Acceptable][Unacceptable][N/A]
6. Were routine/preventative maintenance items clearly identified? [Acceptable][Unacceptable][N/A]
7. Was the lubrication schedule (if any) discussed? [Acceptable][Unacceptable][N/A]
8. Was the representative able to answer all questions? [Acceptable][Unacceptable][N/A]
9. Did the representative agree to research and answer unanswered questions? [Acceptable][Unacceptable][N/A]

10. Comments: ________________________________

11. Overall Rating: [Satisfactory][Unsatisfactory]

**Note:**

Sessions judged “Unsatisfactory” by a majority of attendees shall be revised and conducted again until a satisfactory rating is achieved.
## COMMISSIONING ROLES AND RESPONSIBILITIES MATRIX

<table>
<thead>
<tr>
<th>NO.</th>
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<th>ENGINEER</th>
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**Process Operational Period**

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**PCIS Optimization and Fine-Tuning**

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<td>As specified in Section 17950 - Testing, Calibration, and Commissioning</td>
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<td>Lead</td>
<td>Review</td>
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</table>

**Legend:**
- **Lead:** Primarily responsible for organization, coordination, and execution of task work product or result.
- **Support:** Assist the lead with organization, coordination, and execution of task work product or result.
- **Witness:** Observe and document completion of task work product or result.
- **Review:** As necessary to accept task work product result.
- **No Action:** Limited or no involvement.
SECTION 01770
CLOSEOUT PROCEDURES

PART 1  GENERAL

1.01  SUMMARY

A. Section includes: Contract closeout requirements including:
   1. Final cleaning.
   2. Waste disposal.
   3. Touch-up and repair.
   4. Disinfection of systems.
   5. Preparation and submittal of closeout documents.

1.02  REFERENCES

A. American Water Works Association (AWWA).

1.03  FINAL CLEANING

A. Perform final cleaning prior to inspections for Final Acceptance.

B. Employ skilled workers who are experienced in cleaning operations.

C. Use cleaning materials that are recommended by manufacturers of surfaces to be cleaned.

D. Prevent scratching, discoloring, and otherwise damaging surfaces being cleaned.

E. Broom clean exterior paved surfaces and rake clean other surfaces of site work:
   1. Police yards and grounds to keep clean.

F. Remove dust, cobwebs, and traces of insects and dirt.

G. Clean grease, mastic, adhesives, dust, dirt, stains, fingerprints, paint, blemishes, sealants, plaster, concrete, and other foreign materials from sight-exposed surfaces, and fixtures and equipment.

H. Remove non-permanent protection and labels.

I. Clean light fixtures and replace burned-out or dim lamps.
1.04 WASTE DISPOSAL

A. Arrange for and dispose of surplus materials, waste products, and debris off-site:
   1. Prior to making disposal on private property, obtain written permission from District of such property.

B. Do not fill ditches, washes, or drainage ways that may create drainage problems.

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

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

E. Complete leveling and cleanup prior to final acceptance of the Work.

1.05 TOUCH-UP AND REPAIR

A. Touch-up or repair finished surfaces on structures, equipment, fixtures, and installations that have been damaged prior to inspection for Final Acceptance.

B. Refinish or replace entire surfaces that cannot be touched up or repaired satisfactorily.

1.06 FINAL CLEANING AND DISINFECTION OF PLANT FACILITIES

A. Clean pipe and basins, before running of 7-day test, or before facility goes on stream when 7-day test is not required. Wash, wherever practicable, or broom sweep pipe and basins.

1.07 CLOSEOUT DOCUMENTS

A. Submit following Closeout Submittals upon completion of the Work and at least 7 days prior to submitting Application for Final Payment:
   1. Project Record Documents.
   2. Operation and Maintenance Manuals.
   3. Warranties and Bonds.
   4. Evidence of Payment and Release of Stop Payment Notices as outlined in Conditions of the Contract.
   5. Release of claims as outlined in Conditions of the Contract.
   6. Survey Record Documents as specified in Section 01722 - Field Engineering.
   7. Certificate of Final Completion.

1.08 PROJECT RECORD DOCUMENTS

A. Maintain at Project site, available to District and Engineer, 1 copy of the Contract Documents, shop drawings, and other submittals in good order:
   1. Mark and record field changes and detailed information contained in submittals and change orders.
2. Record actual depths, horizontal and vertical location of underground pipes, duct banks, and other buried utilities. Reference dimensions to permanent surface features.

3. Identify specific details of pipe connections, location of existing buried features located during excavation, and the final locations of piping, equipment, electrical conduits, manholes, and pull boxes.

4. Identify location of spare conduits including beginning, ending, and routing through pull boxes and manholes. Record spare conductors, including number and size, within spare conduits and filled conduits.

5. Provide schedules, lists, layout drawings, and wiring diagrams.

6. Make annotations with erasable colored pencil conforming to the following color code:

<table>
<thead>
<tr>
<th>Additions:</th>
<th>Red</th>
</tr>
</thead>
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<tr>
<td>Deletions:</td>
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</tr>
<tr>
<td>Comments</td>
<td>Blue</td>
</tr>
<tr>
<td>Dimensions:</td>
<td>Graphite</td>
</tr>
</tbody>
</table>

B. Maintain documents separate from those used for construction:
   1. Label documents "RECORD DOCUMENTS."

C. Keep documents current:
   1. Record required information at the time the material and equipment is installed and before permanently concealing.

D. Deliver record documents with transmittal letter containing date, Project title, Contractor's name and address, list of documents, and signature of Contractor.

E. During progress meetings, record documents will be reviewed to ascertain that changes have been recorded.

1.09 WARRANTIES AND BONDS

A. Provide executed Warranty or Guaranty Form if required by Contract Documents.

B. Provide specified additional warranties, guarantees, and bonds from manufacturers and suppliers.

1.10 CERTIFICATE OF FINAL COMPLETION

A. When 7-day operational test has been successfully completed, Engineer will certify that new facilities are operationally complete. Engineer will submit a list of known items (punch list) still to be completed or corrected prior to contract completion.

B. List of items to be completed or corrected will be amended as items are resolved by Contractor.
C. When all items have been completed or corrected, submit written certification that the entire work is complete in accordance with the Contract Documents and request final inspection.

D. Upon completion of final inspection, Engineer will either prepare a written acceptance of the entire work or advise Contractor of work not complete. If deemed necessary by Engineer, inspection procedures will be repeated.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION
SECTION 02050

SOILS AND AGGREGATES FOR EARTHWORK

PART 1 GENERAL

1.01 SUMMARY

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

1.02 REFERENCES

A. ASTM International (ASTM):

B. California - California State Transportation Agency, Department of Transportation (CALTRANS):
   2. California Test Methods (CTM):
      d. California Test 229 - Method of Test for Durability Index.
      e. California Test 301 - Method of Test for Determining the Resistance "R" Value of Treated and Untreated Bases, Subbases, and Basement Soils by the Stabilometer.
1.03 SUBMITTALS

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

B. Quality control for aggregate base course:
   1. Test reports: Reports for tests required by Sections of Standard Specifications.
   2. Certificates of Compliance: Certificates as required by Sections of Standard Specifications.

1.04 DELIVERY, STORAGE, AND HANDLING

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

PART 2 PRODUCTS

2.01 MATERIALS - GENERAL

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

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

2.02 NATIVE MATERIAL

A. Native soil:
   1. Sound, earthen material.
   2. Expansion index less than 35 when tested in accordance with ASTM D4829.
   3. Conforms to size and grade within the following limits when tested in accordance with ASTM C117 and ASTM C136:

<table>
<thead>
<tr>
<th>Sieve Sizes (Square Openings)</th>
<th>Percent by Weight Passing Sieve</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-inch</td>
<td>100</td>
</tr>
<tr>
<td>Number 200</td>
<td>30 maximum</td>
</tr>
</tbody>
</table>

2.03 AGGREGATE BASE COURSE

A. Material requirements:
   1. Class 2, 3/4-inch maximum aggregate size, free from organic matter and other deleterious substances, and of such nature that aggregate can be compacted readily under watering and rolling to form a firm, stable base.
2. Aggregate base course for structures:
   a. Consist of crushed or fragmented particles.
   b. Coarse aggregate material retained in Number 4 sieve shall consist of
      material of which at least 25 percent by weight shall be crushed particles
      when tested in accordance with California Test 205.

3. Aggregate shall not be treated with lime, cement, or other chemical material.

4. Durability index: Not less than 35 when tested in accordance with California
   Test 229.

5. Aggregate grading and sand equivalent tests shall be performed to represent
   not more than 500 cubic yards or 1 day's production of material, whichever is
   smaller.

6. Sand equivalent: Not less than 25 when tested in accordance with California
   Test 217.

7. Resistance (R-value): Not less than 78 when tested in accordance with
   California Test 301.

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

<table>
<thead>
<tr>
<th>Sieve Sizes (Square Openings)</th>
<th>Percent by Weight Passing Sieve</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 inch</td>
<td>100</td>
</tr>
<tr>
<td>3/4 inch</td>
<td>90 - 100</td>
</tr>
<tr>
<td>Number 4</td>
<td>35 - 60</td>
</tr>
<tr>
<td>Number 30</td>
<td>10 - 30</td>
</tr>
<tr>
<td>Number 200</td>
<td>2 - 9</td>
</tr>
</tbody>
</table>

2.04 GRAVEL

A. Material requirements:
   1. Consists of hard, durable particles of stone or gravel; or crushed to the
      specified sizes and gradations; and free from organic matter, lumps or balls of
      clay, and other deleterious matter.
   2. Crush or waste coarse material and add or waste fine material in order to
      meet the specified gradations.
   3. Fraction of material passing Number 40 sieve: Material having plasticity index
      not greater than 5 when tested in accordance with ASTM D4318.
   4. Durability: Percentage of wear not greater than 40 percent when tested in
      accordance with California Test 211.
   5. Conform to sizes and grade within the following limits when tested in
      accordance with ASTM C117 and C136:
### Sieve Size (Square Openings) | Percent by Weight Passing Sieve
--- | --- | --- | ---
Type A | Type B | Type C
2 inch | 100 | -- | --
1-1/2 inch | 95 - 100 | 100 | --
3/4 inch | 35 - 60 | 55 - 85 | 100
3/8 inch | 15 - 40 | 35 - 65 | 50 - 100
Number 4 | 0 - 25 | 20 - 35 | 30 - 45
Number 30 | -- | 5 - 15 | 10 - 20
Number 200 | 0 - 5 | 2 - 9 | 2 - 9

#### 2.05 DRAIN ROCK

A. Material requirements:
   1. Durability index: Percentage of wear not greater than 40 when tested in accordance with California Test 229.
   2. Consists of hard, durable particles of stone or gravel; screened or crushed to specified size and gradation; and free from organic matter, lumps or balls of clay, or other deleterious matter.
   3. Crush or waste coarse material and waste fine material as required to meet gradation requirements.
   4. Conforms to size and grade within the following limits when tested in accordance with ASTM C117 and C136:

   | Sieve Size (Square Openings) | Percent By Weight Passing Sieve
--- | ---
2 inch | 100
1-1/2 inch | 95 - 100
3/4 inch | 50 - 100
3/8 inch | 15 - 55
Number 200 | 0 - 2

#### 2.06 SAND

A. Clean, coarse, natural sand.

B. Non-plastic when tested in accordance with ASTM D4318.
C. Conforms to size and grade within the following limits when tested in accordance with ASTM C117 and C136:

<table>
<thead>
<tr>
<th>Sieve Size (Square Openings)</th>
<th>Percent by Weight Passing Sieve</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2 inch</td>
<td>100</td>
</tr>
<tr>
<td>Number 200</td>
<td>0 - 20</td>
</tr>
</tbody>
</table>

### 2.07 STABILIZATION MATERIAL

A. Durability percentage of wear not greater than 40 percent when tested in accordance with California Test 211.

B. Consists of clean, hard, durable particles of crushed rock or gravel; screened or crushed to the specified sizes and gradations; and free of any detrimental quantity of soft, friable, thin, elongated, or laminated pieces, disintegrated material, organic matter, oil, alkali, or other deleterious substance.

C. Shall be free of slaking or decomposition under the action of alternate wetting and drying.

D. The portion of material retained on the 3/8-inch sieve shall contain at least 50 percent of particles having 3 or more fractured faces. Not over 5 percent shall be pieces that show no such faces resulting from crushing. Of that portion which passes the 3/8-inch sieve but is retained on the Number 4 sieve, not more than 10 percent shall be pieces that show no faces resulting from crushing.

E. Conforms to size and grade when tested in accordance with ASTM C117 and ASTM C136.

<table>
<thead>
<tr>
<th>Sieve Size (Square Openings)</th>
<th>Percent by Weight Passing Sieve</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 inch</td>
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<tr>
<td>Number 4</td>
<td>0 - 10</td>
</tr>
<tr>
<td>Number 200</td>
<td>0 - 2</td>
</tr>
</tbody>
</table>

### PART 3 EXECUTION

Not Used.

END OF SECTION
SECTION 02084

PRECAST DRAINAGE STRUCTURES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Onsite utility structures:
   1. Precast drainage inlets.

1.02 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO):

B. ASTM International (ASTM):

1.03 SYSTEM DESCRIPTION

A. Performance requirements:
   1. Appurtenances: Appurtenances shall be watertight and free from infiltration or exfiltration.

1.04 SUBMITTALS

A. Shop Drawings: Submit shop drawings for precast utility structures.

PART 2 PRODUCTS

2.01 MANUFACTURED UNITS

A. Precast drainage inlets:
   1. Construct precast concrete drainage inlets in accordance with the size, shape, form, details, and at locations indicated on the Drawings and specified.
   2. Base design and manufacture to A-16 (HS 20-44) loading in accordance with ASTM C857.
   3. In accordance with ASTM C858.
4. Construct precast drainage inlets of Class D concrete as specified in Section E03300 - Cast-in-Place Concrete to form and dimensions indicated on the Drawings.

2.02 ACCESSORIES

A. Precast drainage inlets:
   1. Covers: As indicated on the Drawings.

PART 3 EXECUTION

3.01 INSTALLATION

A. Precast drainage inlets:
   1. Excavation and backfill: As specified in Section 02318 - Trenching.

END OF SECTION
SECTION 02085
PRECAST CONCRETE VAULTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Precast concrete vaults.

1.02 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO):
   1. LRFD Bridge Design Specifications.

B. American Concrete Institute (ACI):
   1. 318 - Building Code Requirements for Structural Concrete and Commentary.

C. ASTM International (ASTM):

D. Occupational Safety and Health Administration (OSHA).

1.03 SUBMITTALS

A. General:
   1. Furnish submittals as specified in General Conditions.

B. Shop drawings:
   1. Show dimensions, locations, lifting inserts, reinforcement, and joints.
   2. Structural design calculations for vaults, signed by a civil or structural engineer licensed in the State of California.

C. Manufacturer’s Certification for Vaults: Written certification that the vault complies with the requirements of this Section.

1.04 QUALITY ASSURANCE

A. Inspection:
   1. After installation, the Contractor shall demonstrate that vaults have been properly installed, level, with tight joints, at the correct elevations and
orientations, and that the backfilling has been carried out in accordance with the Contract Documents.

PART 2  PRODUCTS

2.01 VAULTS

A. Manufacturers: One of the following or equal:
   1. Oldcastle Precast.
   2. Jensen Precast.

B. Provide precast vaults for the size indicated on the Drawings.

C. The minimum structural member thickness for vaults shall be 5 inches:
   1. Cement shall be Type V portland cement in accordance with ASTM C150.
   2. The minimum 28-day concrete compressive strength shall be 4,000 pounds per square inch.
   3. All reinforcing steel shall be embedded in the concrete with a minimum clear cover as recommended by ACI 318.

D. Design requirements: Loads on structures:
   1. In accordance with ASTM C857, except as modified in this Section.
   2. Loads at the ground surface:
      a. “Roadway”: Load from heavy, frequently repeated vehicle traffic:
         1) ASTM C857, Table 1, Designation A-16 (AASHTO HS20-44).
      3. Loads against walls. Include effects of groundwater and seismic accelerations on earth pressures:
         a. Equivalent lateral pressure:
            1) Triangular distribution: 70 pounds per square foot per foot of depth (triangular distribution).
            2) Rectangular distribution backfill-induced live load surcharge: 240 pounds per square foot.
      b. Surface surcharge load: In accordance with ASTM C857 A-16 wheel load if such surcharge exceeds backfill loads described in the preceding paragraph.
      c. Groundwater effects: Include groundwater effects on lateral earth pressure loads using design elevation of 1447:
         1) Use equivalent lateral pressure of 90 pounds per square foot per foot of depth (triangular distribution) for soil below the design groundwater elevation.
      d. Seismic acceleration effects:
         1) As specified in Section 01612 - Seismic Design Criteria.
         2) On opposite sides of the structure, uniform equivalent lateral leave in pressure type distribution, with a pressure of 37.5 in pounds per square foot where it is the depth of structure.
3) Adding lateral force for soil accelerating toward structure:
   a) Direct uniform pressure distribution toward the wall, effectively increasing the static lateral soil pressure.

4) Reducing lateral force for soil accelerating away from structure:
   a) Direct inverted pressure distribution away from the wall, effectively reducing the static lateral soil pressure.

4. Groundwater and flood loads, and buoyancy effects:
   a. As specified in Geotechnical Report for design groundwater elevations.
   b. Lateral pressure effects: Determine based on groundwater and flood elevations specified.
   c. Buoyancy: For groundwater and flood conditions, provide factor of safety against flotation of at least 1.20:
      1) If the weight of soil overlying footing projections on the structure is considered to resist flotation, use a buoyant unit weight of soil equal to not more than 60 pounds per cubic foot.
      2) Concrete fill may be provided in the bottom section of precast portland cement concrete structures to add weight. Submit proposed details.

5. Soil bearing pressure at base:
   a. Maximum 4,000 pounds per square foot total pressure on prepared subgrade soils.

6. Lifting and handling loads:
   a. Make provision in the design for the effects of loads or stresses that may be imposed on structures during fabrication, transportation, or erection.

7. Load combinations:
   a. Design structures to sustain the specified loads individually or in combination.

E. Design requirements: Structural analysis, design and detailing:
   1. Analyze and design structures including the effects of 2-way action (“plate action”) and of load transfer around current and future openings.
   2. Where structures include panels designed for future removal (“knockout panels”), design structures for loads and stresses with any combination of any or all such panels in place or removed.
   3. Design structures in accordance with the requirements of ACI 318 and this Section.
   4. Provide reinforcement at all areas subject to tensile stress when loaded with the specified loads and combinations thereof.
   5. Provide temperature and shrinkage reinforcement to equal or exceed ACI 318 requirements in all concrete sections.
   6. Provide minimum clear concrete cover over reinforcement at both interior and exterior faces of all members in accordance with the following:
      a. Vaults: 2 inches.
7. Reinforcement details:
   a. Walls: For structures with wall thickness of 8 inches or less, locate a single mat of reinforcement at the center of the wall.
   b. Slabs: For structures with slab thickness of 7 inches or less, locate a single mat of reinforcement at the center of the slab.
   c. Structures with wall or slab thicknesses exceeding these limits shall have a reinforcement at each face of the member.

8. Joints:
   a. Provide structures with watertight joints between sections, and detailed to minimize water infiltration at duct bank and conduit penetrations.
   b. Provide structures with non-skid, shiplap, or tongue and groove joints between sections.

F. Design requirements: Materials:
   1. Portland cement concrete vaults:
      a. In accordance with ASTM C858, except as modified in this Section.
      b. Proportion concrete mixes to resist damage from freezing and thawing in a moist environment, and for exposure to deicing chemicals. In accordance with ACI 318 requirements for minimum specified compressive strength and air entrainment.
   2. Seal joints watertight with precast concrete joint sealant as specified in Section 07900 - Joint Sealants.

G. Where joints are designed in pre-cast concrete vaults, such joints shall be interlocking to secure proper alignment between members and prevent migration of soil through the joint. Structural sections at joints shall be sized sufficiently to reinforce the section against localized distress during transportation and handling and against excess contact bearing pressures through the joint.

H. Vault shall be solid walled construction:
   1. Where penetration of the pre-cast concrete vault are required for piping, conduit, or ducts, such penetrations shall be accommodated through pre-cast openings or core-drilled sections.
   2. Openings for penetrations shall be smooth and free of surface irregularities and without exposed steel reinforcing.
   3. Vaults need not be designed to resist thrust from piping passing through the vault.
   4. Coordinate pipe penetration locations with piping arrangement as indicated on the Drawings.

I. Slope bottom of vault to Drainage Sump as indicated on the Drawings.
J. Drainage Sump: Dimensions as indicated on the Drawings:
   1. Drainage Sump shall consist of an open knockout in the bottom of the vault. Provide additional reinforcing as required to accommodate knockout.
   2. Provide FRP grating with rebate as indicated on the Drawings:
      a. Grating shall be designed for 300 pounds per square foot load with L/200 maximum deflection.
      b. Provide removable grating sections to facilitate grating removal without disconnecting Automatic Sump Drain Ejector Assembly indicated on the Drawings.

K. Ladders:
   1. General:
      a. Type:
         1) Safety type conforming to local, State, and OSHA standards as minimum.
         2) Furnish guards for ladder wells.
      b. Size: 18 inches wide between side rails of length, size, shape, detail, and location indicated on the Drawings.
   2. Aluminum ladders:
      b. Rungs:
         1) 1-inch minimum solid square bar with 1/8-inch grooves in top and deeply serrated on all sides.
         2) Capable of withstanding 1,000 pound load without failure.
      c. Side rails: Minimum 4-inch by 1/2-inch flat bars.
      d. Fabrication:
         1) Welded construction, of size, shape, location, and details indicated on the Drawings.

2.02 ACCESS HATCH

A. Where openings for access to the vault are required, the full clear space opening indicated shall be provided, without obstructions from brackets or supports. For large openings where brackets or supports are designed to protrude into the opening for support of required covers, such brackets or supports shall be designed to be easily removed and replaced with a minimum of effort and without cutting or welding.

2.03 COATINGS

A. Coat interior and exterior of valve vault in accordance with Section 09960 - High-Performance Coatings or as indicated on the Drawings.
PART 3 EXECUTION

3.01 INSTALLATION

A. Pre-cast concrete sections shall be transported and handled with care in accordance with the manufacturer’s written recommendations:
   1. Where lifting devices are provided in pre-cast sections, such lifting devices shall be used as intended.
   2. Where no lifting devices are provided, the Contractor shall follow the manufacturer’s recommendations for lifting procedures to provide proper support during lifting.

B. Buried pre-cast concrete vaults shall be assembled and placed in excavations on properly compacted soil foundations as indicated. Pre-cast concrete vaults shall be set to grade and oriented to provide the required dimensions and clearances from pipes and other structures.

C. Apply coatings in accordance with manufacturer's instructions.

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

END OF SECTION
SECTION 02200
SITE CLEARING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Clearing project site.

1.02 DEFINITIONS

A. Clearing: Consists of removal of natural obstructions and existing foundations, buildings, fences, lumber, walls, stumps, brush, weeds, rubbish, trees, boulders, utility lines, and any other items which interferes with construction operations or are designated for removal.

B. Grubbing: Consists of the removal and disposal of wood or root matter below the ground surface remaining after clearing and includes stumps, trunks, roots, or root systems greater than 1 inch in diameter or thickness to a depth of 6 inches below the ground surface.

1.03 QUALITY ASSURANCE

A. Regulatory requirements: Verify and comply with applicable regulations regarding those governing noise, dust, nuisance, drainage and runoff, fire protection, and disposal.

B. Pre-construction conference: Meet with Engineer to discuss order, sequence, and method of work.

1.04 PROJECT CONDITIONS

A. Environmental requirements:
   1. For suspected hazardous materials found: As specified in General Conditions

1.05 SEQUENCING AND SCHEDULING

A. Clearing and grubbing: Perform clearing and grubbing in advance of grading operations in a sequence acceptable to Engineer.

PART 2 PRODUCTS

Not Used.
PART 3  EXECUTION

3.01  EXAMINATION

A. Verification of conditions: Examine site and verify existing conditions for beginning work.

3.02  PREPARATION

A. Protect existing improvements from damage by site preparation work.

3.03  INSTALLATION

A. Clearing:
   1. Clear areas where construction is to be performed and other areas as indicated on the Drawings or specified in this Section, of fences, lumber, walls, stumps, brush, roots, weeds, trees, shrubs, rubbish, and other objectionable material of any kind which, if left in place, would interfere with proper performance or completion of the work, would impair its subsequent use, or form obstructions.
   2. Do not incorporate organic material from clearing and grubbing operations in fills and backfills.
   3. Contractor’s temporary construction facilities: Fill or remove pits, fill, and other earthwork required for erection of facilities, upon completion of the work, and level to meet existing contours of adjacent ground.

B. Grubbing:
   1. From excavated areas: Grub stumps, roots, and other obstructions 3 inches or over in diameter to depth of not less than 18 inches below finish grade.
   2. In embankment areas or other areas to be cleared outside construction area: Do not leave stumps, roots, and other obstructions higher than the following requirements:

<table>
<thead>
<tr>
<th>Height of Embankment Over Stump or Root</th>
<th>Depth of Clearing and Grubbing</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Heights</td>
<td>Grub stumps or roots 3 inches or over in diameter to 18 inches below original grade. Cut others flush with ground.</td>
</tr>
</tbody>
</table>

   3. Backfill and compact cavities left below subgrade elevation by removal of stumps or roots to density of adjacent undisturbed soil.
C. Material reuse and recycling:
   1. 100 percent of trees, stumps, rocks and associated vegetation and soils resulting primarily from land clearing shall be reused or recycled. For a phased project, such material may be stockpiled on site until project completion.
   2. Contractor shall provide Engineer with list of local markets and salvage sites for reuse of clearing debris.

END OF SECTION
SECTION 02240
DEWATERING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Installation and maintenance of dewatering systems.
   2. Disposal of water entering excavation or other parts of the work.

1.02 REFERENCES

A. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).

1.03 DEFINITIONS

A. NEMA Type 4X enclosure in accordance with NEMA 250.

1.04 SYSTEM DESCRIPTION

A. Design requirements:
   1. Keep excavations reasonably free from water. Draw down static groundwater level to minimum of 3 feet below anticipated bottom of excavations before the excavation reaches bottom elevation.
   2. Dewatering design analysis. Include the following:
      a. Evaluation of anticipated subsurface conditions.
      b. Required well spacing.
      c. Diameter of wells.
      d. Depth to screen, screen height, and mesh size.
      e. Backfill and filter pack.
      f. Pump size.
      g. Drawdown duration.
      h. Drawdown and steady state flow rates.
      i. Plans for de-silting of groundwater before discharge.
      j. Expected settlements.
   3. Include water drawdown curves in dewatering calculations.
   4. Coordinate dewatering design with excavation and shoring design. Excavation and shoring design shall consider changes in groundwater conditions and associated earth pressures.
   5. Do not place concrete or masonry foundations or concrete slabs in water. Do not allow water to rise over these elements until concrete or mortar has set for at least 24 hours.
6. Maintain operation of dewatering system until complete structure -- including walls, slabs, beams, struts, and other structural elements -- has been constructed; concrete has attained its specified compressive strength; and backfill has been completed to 3 feet above normal static groundwater level at the site.

7. Provide standby power to ensure continuous dewatering in case of power failure.

B. Dewatering shored excavations:
   1. Dewater from within shoring.
   2. Use impermeable shoring system to minimize lowering of groundwater outside shoring.
   3. Extend impermeable shoring below bottom of excavation sufficient amount to:
      a. Minimize lowering of groundwater outside shoring.
      b. Prevent unstable excavation due to piping and heave.
   4. To minimize settlement outside shoring due to dewatering, do not lower groundwater outside shoring more than 1 foot. Provide groundwater recharge if required to maintain this groundwater elevation outside of shoring.
   5. Provide monitoring wells located outside shoring for monitoring groundwater elevation.

C. Obtain written permission from Engineer before locating wells, well points, or drain lines for dewatering within the limits of a structure's foundation.

D. Locate dewatering facilities where they will not interfere with utilities and construction work to be performed by others.

E. Discharge:
   1. Discharge water to Out-of-Compliance Ponds.

1.05 SUBMITTALS

A. Dewatering plan:
   1. Dewatering design analysis.
   2. Required permits.
   3. Arrangement, location, and depths of dewatering system components.
   4. Type and sizes of filters.
   5. Identify proposed alignment, support, and protection for discharge pipe. Identify location of discharge and provide details for that location.

B. Well construction logs. Include:
   1. Descriptions of actual materials encountered, categorized in accordance with Unified Soil Classification System.
   2. Construction details.
   3. Well development procedures and results.
4. Deviations from original design.

C. Qualifications:
   1. Dewatering contractor.
   2. Dewatering design engineer.
   3. Testing laboratory.

1.06 QUALITY ASSURANCE

A. Dewatering plan and dewatering system analysis:
   1. Prepared by a qualified civil engineer, licensed in the state where the Project is located:
      a. The dewatering design engineer shall have at least 8 years of experience in designing similar systems.

B. Dewatering Contractor shall have at least 8 years of experience in installing similar systems.

C. Testing laboratory shall meet discharge permit testing laboratory qualifications.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 INSTALLATION

A. During construction, provide and maintain ample means and devices to promptly remove and properly dispose of water entering excavation or other parts of the work, whether water is surface water or underground water.

B. Keep excavations reasonably free of water.

C. Make provisions to maintain continuous dewatering:
   1. Provide standby power to maintain dewatering during power outages and interruptions.
   2. Provide 24-hour monitoring by personnel skilled in operation and maintenance of the system, and capable of providing or obtaining work required to maintain system operation.

D. Monitoring wells:
   1. Provide at least 1 groundwater level monitoring well. If more than 4 dewatering wells or well points are installed, provide 1 additional monitoring well for every 4 dewatering wells or well points.
2. Locate monitoring wells within 6 feet of excavation and mid-way between
dewatering wells or well points.
3. Provide temporary threaded cap, not less than 2 inches in diameter at the top
of wells.
4. Protect dewatering wells in place during excavation.
5. When requested by Engineer, leave monitoring wells in place after
excavations are backfilled.

E. Intercept and divert precipitation and surface water away from excavations. Use
dikes, curb walls, ditches, pipes, sumps, or other means acceptable to Engineer.

F. Disposal of water:
1. Dispose of water from the work in suitable manner without damage to
adjacent property.
2. Do not drain water into work built or under construction.
3. Dispose of water in such manner that it will not be a menace to public health
or safety.

G. Wells, well points, and drain lines for dewatering:
1. Provide after receiving Engineer’s written acceptance.
2. Fill dewatering wells, pipes, and french drains to be left in place within
structure foundation limits with Class “C” concrete as specified in
Section E03300 - Cast-in-Place Concrete or grout as specified in
Section 03600 - Grouting.

3.02 CONSTRUCTION

A. Prior to release of groundwater to its static level: Confirm that:
1. All groundwater pressure relief devices for structure are fully operational.
2. Construction of structure is complete and concrete has reached its specified
compressive strength.
3. Backfill of structure is complete.

B. Control release of groundwater to its static level to prevent disturbance of natural
foundation soils or compacted backfills and fills and to prevent flotation or
movement of structures, pipelines, or other facilities.

3.03 FIELD QUALITY CONTROL

A. Monitoring wells:
1. Record groundwater levels at least once a week. Submit readings to Engineer
within 1 week.

END OF SECTION
PART 1  GENERAL

1.01  SUMMARY

A. Section includes: Requirements for designing, providing, maintaining, and removing excavation support and protection.

1.02  REFERENCES

A. American Society of Civil Engineers (ASCE):

B. California Code of Regulations (CCR):
   1. Title 8 - Industrial Relations:
      a. Division 1. Department of Industrial Relations:
         1) Chapter 4. Division of Industrial Safety:
            a) Subchapter 4. Construction Safety Orders:

C. Department of the Navy Naval Facilities Engineering Command (NAVFAC):
   2. Design Manual 7.3 - Soil Dynamics and Special Design Aspects.

D. State of California Department of Transportation (Caltrans):

E. United States Steel Corporation (USS):
   1. Steel Sheet Piling Design Manual.

1.03  DEFINITIONS

A. General Engineering Design Practice: General engineering design practice in area of the Project, performed in accordance with recent engineering literature on subject of shoring and stability of excavations.

B. Shoring: A temporary structural system designed to support vertical faces, or nearly vertical faces, of soil or rock for purposes of excavation. Shoring includes cantilevered sheet piling, internally braced sheet piling, slurry walls, soldier piles and lagging, and other similar shoring systems. Sloping of the soil is not shoring.

C. Support levels: Level of tiebacks, wales, rackers, bottom of excavation, and other types of support.
1.04 SYSTEM DESCRIPTION

A. Where General Engineering Design Practice is specified, provide drawings and calculations that are performed and signed by civil or structural engineer registered in the State of California:
   1. Clearly disclose assumptions made, criteria followed, and stress values used for materials being used in design calculations.
   2. Submit list of references acceptable to Engineer that substantiating appropriateness of design assumptions, criteria, and stress values.

B. Design requirements:
   1. General:
      a. In accordance with requirements in CCR, Title 8, Chapter 4, Subchapter 4, Article 6 for trench excavations 5 feet or more in depth and for trenches less than 5 feet in depth when there is potential for cave-in:
         1) Where such designs vary from excavation support standards set forth in CCR, Title 8, Chapter 4, Subchapter 4, Article 6, submit design calculations pursuant to general engineering design practice.
         2) Provide means for safe and stable excavations that are not less effective than required in CCR, Title 8, Chapter 4, Subchapter 4, Article 6.
         3) The preceding requirements do not apply to trench excavation support conforming to standards set forth CCR, Title 8, Chapter 4, Subchapter 4, Article 6.
      b. Dewatering:
         1) Dewater soil inside shoring.
         2) Do not lower groundwater outside of shoring more than 1 foot.
         3) Recharge groundwater outside shoring to limit groundwater draw down outside of shoring to amount specified above.
      c. When electing to design with material stresses for temporary construction higher than allowable stresses prescribed in building code as specified in Section 01410 - Regulatory Requirements, increase in such stresses shall not exceed 10 percent of value of prescribed stresses.
      d. Minimum safety factor used for design shall not be less than 1.5.
      e. The calculated minimum depth of penetration of shoring below bottom of excavation shall be increased not less than 30 percent if full value of allowable passive pressure is used in design.
      f. Maximum height of cantilever shoring above bottom of excavation shall not exceed 15 feet. Use braced shoring when height of shoring above bottom of excavation exceeds 15 feet.
      g. The location of point of fixity for shoring shall not be less than half calculated minimum embedment depth below bottom of excavation.
h. Generally acceptable references for design of shoring and excavations are as follows:
   1) ASCE Guidelines of Engineering Practice for Braced and Tied-Back Excavations.
   3) NAVFAC Design Manual 7.2.
   4) NAVFAC Design Manual 7.3.
   5) USS Steel Sheet Piling Design Manual.

i. Shoring engineering firm shall obtain errors and omissions insurance for Project for an amount of not less than 500,000 dollars.

2. Soldier piles and lagging:
   a. Provide lagging over full face of excavation. Joints between pieces of lagging shall be tight to prevent loss of soil.
   b. Provide full face lagging all around penetrations through lagging.
   c. If the soldier piles are installed in predrilled holes and are not concrete encased, fill predrilled holes with controlled low strength material as specified in Section E02252 - Control Density Fill after soldier piles are installed.
   d. Assumed effective width for passive soil resistance:
      1) Effective width of driven soldier piles shall not exceed 2 times width of pile.
      2) Effective width of CLSM encased soldier piles in drilled holes shall not exceed 2 times width of pile.
      3) Effective width of concrete encased soldier piles shall not exceed 2 times width of concrete encasement.
   e. Fill voids behind lagging with gravel or other material acceptable to Engineer.
   f. Apply loads from tie back soil, rock, or deadman anchors concentrically to soldier piles or wales spanning between soldier piles:
      1) Wales shall be back-to-back double channels or other members acceptable to Engineer.
      2) Do not eccentrically load structural section of soldier piles or wales.
   g. Design soldier piles for downward loads including vertical loads from tieback anchors.

3. Soil anchors, rock anchors, and deadman anchors:
   a. Design tieback anchors for a safety factor of not less than 2 times calculated load from shoring.
   b. Proof load all production anchors to 150 percent of calculated load from shoring.
   c. Lock off production anchors at calculated load from shoring.
   d. Length of soil anchors used to calculate resistance to load from shoring shall not include any length within potential active pressure soil failure zone behind face of shoring.
   e. Design tie rods for tieback anchors for 130 percent of calculated load from shoring.
f. Design tie rods for tieback anchors for 150 percent of the calculated load from shoring when tie rod couplers are used and for other conditions where stress concentrations can develop.

4. Set inside face of shoring back from structure not less than greater of following:
   a. 5 feet from face of wall.
   b. 2 foot 6 inches from edge of foundation.
   c. Depth of excavation below bottom of foundation.

C. Performance requirements:
   1. General:
      a. Support faces of excavations and protect structures and improvements in vicinity of excavations from damage and loss of function due to settlement or movement of soils, alterations in ground water level caused by such excavations, and related operations.
      b. Specified provisions:
         1) Complement, but do not substitute or diminish, obligations of Contractor for furnishing of safe place of work pursuant to provisions of the Occupational Safety and Health Act of 1970 and its subsequent amendments and regulations and for protection of Work, structures, and other improvements.
         2) Represent minimum requirement for:
            a) Number and types of means needed to maintain soil stability.
            b) Strength of such required means.
            c) Methods and frequency of maintenance and observation of means used for maintaining soil stability.
   2. Provide safe and stable excavations by means of sheeting, shoring, bracing, sloping, and other means and procedures, such as draining and recharging groundwater and routing and disposing of surface runoff, required to maintain stability of soils and rock.
   3. Provide support for trench excavations for protection of workers from hazard of caving ground.
   4. Provide shoring:
      a. Where, as result of excavation work and analysis performed pursuant to general engineering design practice, as defined in this Section:
         1) Excavated face or surrounding soil mass may be subject to slides, caving, or other types of failures.
         2) Stability and integrity of structures and other improvements may be compromised by settlement or movement of soils, or changes in soil load on structures and other improvements.
      b. For trenches 5 feet and deeper.
      c. For trenches less than 5 feet in depth, when there is potential for cave-in.
      d. Where indicated on the Drawings.
5. For safe and stable excavations, use appropriate design, construction, and maintenance procedures to minimize settlement of supported ground and to prevent damage to structures and other improvements, including:
   a. Using stiff shoring systems.
   b. Following appropriate construction sequence.
   c. Using shoring system that is tight enough to prevent soil loss through the shoring.
   d. Using shoring system that extends far enough below bottom of excavation to prevent piping, heave, or flow of soil under shoring.
   e. Design for safety factor of not less than 1.50.
   f. Providing surface runoff routing and discharge away from excavations.
   g. Where dewatering inside shoring is necessary, recharge groundwater outside shoring as necessary to prevent settlement in area surrounding shored excavation.
   h. Where sheet piling is used, use interlocking type sheets:
      1) Sheet piles shall be continuous and driven in interlock.
      2) If bottom of the excavation is located below the water table, use “ball and socket” or "thumb and finger" type interlock.
   i. Not applying shoring loads to existing structures and other improvements.
   j. Not changing existing soil loading on existing structures and other improvements.
   k. Provide welded steel packing between soil retaining members such as sheet piles and wales and similar members when gap exceeds 1/2 inch before wales are loaded.

1.05 SUBMITTALS

A. Shop drawings and calculations:
   1. Calculations for different load, support, and other conditions that occur during the sequence of installation of shoring, construction of facilities protected by shoring, and sequence of removal of shoring.
   2. Sketches showing the condition at various stages of installation and removal of shoring.
   3. Show on plan shoring, structures, pipelines, and other improvements located near shoring.
   4. When utilities penetrate shoring, show location of penetrations on elevation of all sides of shoring.
   5. Show details for ground support and sealing around utility penetrations.
   6. Indicate method used for installing driven shoring.

B. Control points and schedule of measurements:
   1. Submit location and details of control points and method and schedule of measurements.
   2. Survey data.
C. Detailed sequence of installation and removal of shoring:
   1. Consider effects of ground settlement in sequence of installation and removal of shoring.
   2. Provide sketches showing conditions at various stages in sequence of installation and removal of shoring.

D. Submit submittals for excavation support and protection as complete package and include all items required in this Section:
   1. Incomplete submittals will not be reviewed and will be returned for resubmittal as complete package.

E. Submit dewatering submittals as specified in Section 02240 - Dewatering for Structures with submittals for excavation support and protection.

1.06 SEQUENCING

A. Do not begin construction of any shoring or excavation operations until:
   1. Submittals for shoring and dewatering have been accepted.
   2. Control points as specified in this Section and on existing structures and other improvements as indicated on the Drawings have been established and surveyed to document initial elevations and locations.
   3. Materials necessary for installation are on site.

B. Submit submittals minimum of 60 days prior to scheduled date to begin excavation work.

PART 2 PRODUCTS
Not Used.

PART 3 EXECUTION

3.01 CONSTRUCTION

A. Installation of shoring:
   1. Install means for providing safe and stable excavations as indicated in submittals.

B. Removal of shoring:
   1. Except for concrete encased soldier piles, slurry walls, and similar shoring systems, remove shoring by completion of Work.
   2. Select shoring system and method of removal, which will minimize soil that sticks to shoring from creating voids and causing settlement.
   3. To prevent settlement caused by pulling shoring, fill voids with pressure injected grout:
      a. Inject grout starting at bottom of void and progressively fill void to grade.
b. Minimize length of shoring removed ahead of grouting operation and limit time void is left ungrouted to prevent void from closing up before being grouted.

4. Pressure preservative treated wood lagging may be left in place if acceptable to Engineer.

C. Maintenance:
1. Where loss of soil occurs, plug gap in shoring and replace lost soil with fill material acceptable to Engineer.
2. Where measurements and observations indicate possibility of failure or excessive movement of excavation support, determined in accordance with general engineering design practice, take appropriate action immediately.

END OF SECTION
SECTION 02300
EARTHWORK

PART 1    GENERAL

1.01  SUMMARY

A. Section includes:
   1. Loosening, excavating, filling, grading, borrow, hauling, preparing subgrade, compacting in final location, wetting and drying, and operations pertaining to site grading for buildings, basins, reservoirs, boxes, roads, and other facilities.
   2. Backfilling and compacting under and around structures.

1.02  REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO):

B. ASTM International (ASTM):
   2. D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

1.03  DEFINITIONS

A. Backfill adjacent to structure: Backfill within volume bounded by the exterior surfaces of structure, the surface of undisturbed soil in the excavation around structure, and finish grade around structure.

B. Embankments: Dikes, levees, berms, and similar facilities.

C. Excavation: Consists of loosening, removing, loading, transporting, depositing, and compacting in final location, wet and dry materials, necessary to be removed for purposes of construction of structures, ditches, grading, roads, and such other purposes as are indicated on the Drawings.

1.04  SYSTEM DESCRIPTION

A. Performance requirements:
   1. Where mud or other soft or unstable material is encountered, remove such material and refill space with stabilization material. Wrap stabilization material with stabilization fabric.
2. Obtain acceptable import material from other sources if surplus obtained within Project site does not conform to specified requirements or are not sufficient in quantity.
3. No extra compensation will be made for hauling of fill materials nor for water required for compaction.

1.05 SUBMITTALS

A. Copy of Property District’s Agreement allowing placement of surplus soil material on District’s property.

B. Excavation plan.

1.06 QUALITY ASSURANCE

A. Initial compaction demonstration:
   1. Adequacy of compaction equipment and procedures: Demonstrate adequacy of compaction equipment and procedures before exceeding any of following amounts of earthwork quantities:
      a. 50 cubic yards of backfill adjacent to structures.
      b. 100 cubic yards of embankment work.
      c. 100 cubic yards of fill.
      d. 50 cubic yards of roadway base material.
      e. 100 cubic yards of road fill.
   2. Compaction sequence requirements: Until specified degree of compaction on previously specified amounts of earthwork is achieved, do not perform additional earthwork of the same kind.
   3. After satisfactory conclusion of initial compaction demonstration and at any time during construction, provide confirmation tests as specified under "FIELD QUALITY CONTROL."

B. Contractor shall perform all work related to this Section in accordance with the approved Stormwater Pollution Prevention Plan (SWPPP).

1.07 SEQUENCING AND SCHEDULING

A. Schedule earthwork operations to meet requirements specified in this Section for excavation and uses of excavated material.

B. If necessary, stockpile excavated material in order to use it at specified locations.

C. Excavation, backfilling, and filling: Perform excavation, backfilling, and filling during construction in manner and sequence that provides drainage at all times.
PART 2  PRODUCTS

2.01  MATERIALS

A. Water for compacting: Use water from source acceptable to Engineer. See Section 01500 - Temporary Facilities and Controls.

B. Soil and rock materials:
   1. General:
      a. Provide aggregate base course, Class 2 permeable, controlled density fill, drain rock, gravel, native material, sand, select material, and stabilization material where specified or indicated on the Drawings.
      b. If suitable surplus materials are available, obtain native material and select material from cut sections or excavations.
   2. Aggregate base course materials: As specified in Section 02050 - Soils and Aggregates for Earthwork.
   3. Class 2 permeable: As specified in Section 02050 - Soils and Aggregates for Earthwork.
   5. Gravel: As specified in Section 02050 - Soils and Aggregates for Earthwork.
   7. Sand: As specified in Section 02050 - Soils and Aggregates for Earthwork.
   8. Select material: As specified in Section 02050 - Soils and Aggregates for Earthwork.

C. Controlled density fill: As specified in Section E02252 - Control Density Fill.

D. Geotextile fabrics:
   1. Filter fabric: As specified in Section 02620 - Filter Fabric.

PART 3  EXECUTION

3.01  EXAMINATION

A. Verification of conditions:
   1. Character and quantity of material:
      a. Verify character and quantity of rock, gravel, sand, silt, water, and other inorganic or organic materials to be encountered in work to be performed.
      b. Determine gradation, shrinkage, and swelling of soil, and suitability of material for use intended in work to be performed.
      c. Determine quantity of material, and cost thereof, required for construction of backfills, cuts, embankments, excavations, fills, and
roadway fills, whether from onsite excavations. Include in cost of work to be performed.

d. Include wasting of excess material, if required, in cost of work to be performed.

3.02 PREPARATION

A. Backfills:
   1. After clearing and excavation are completed, scarify entire areas that underlie backfills or structures to a depth of 6 inches and until surface is free of ruts, hummocks, and other features that would prevent uniform compaction by equipment to be used.
   2. Recompact scarified areas to density specified before placing backfill material or concrete.
   3. Do not place backfill against walls until:
      a. Walls have been cast full height of structure and concrete has reached the specified strength.
      b. Connecting slabs and beams have been cast, and concrete has reached the specified strength.
   4. Prior to backfilling:
      a. Remove all forms.
      b. Clean all trash and debris from the excavation site.
   5. After inspection of foundation, walls, and pipes, place backfill symmetrically around structures to prevent eccentric loading of structures.

B. Embankments:
   1. After clearing is completed, scarify entire areas that underlie embankments to a depth of 6 inches and until surface is free of ruts, hummocks, and other features that would prevent uniform compaction by equipment to be used.
   2. Recompact scarified areas to density specified for embankments before placing of embankment material.

C. Fills:
   1. After clearing is completed, scarify entire areas that underlie fill sections or structures to a depth of 6 inches and until surface is free of ruts, hummocks, and other features that would prevent uniform compaction by equipment to be used.
   2. Recompact scarified areas to density specified for compacted fills before placing of fill material or concrete.

D. Roadway fills:
   1. After clearing is completed, scarify entire areas that underlie roadway fills to a depth of 6 inches and until surface is free of ruts, hummocks, and other features that would prevent uniform compaction by equipment to be used.
   2. Recompact scarified areas to density specified for roadway fills before placing of roadway fill material.
E. Sloped surfaces for fill or foundations:
   1. Foundations for fill having slopes in excess of 1 vertical to 4 horizontal:
      a. Bench or terrace to adequately key existing ground and fill built thereon.
   2. Slopes of original hillsides and old fills: Bench minimum of 10 feet horizontally as fill is placed.
   3. Provision of new benches:
      a. Start new bench wherever vertical cut of next lower bench intersects existing grade.
      b. Recompact material thus cut out along with new embankment material at no additional cost to the District.

3.03 INSTALLATION

A. General:
   1. Dispose of excavated materials that are not required or are unsuitable for fill and backfill in lawful manner.
   2. Dispose of surplus material on private property only when written permission agreement is furnished by owner of property. Submit copies of such agreements.
   3. Rocks, broken concrete, or other solid materials larger than 4 inches in greatest dimension: Remove from project site at no additional cost to the District.
   4. Stabilization of subgrade: Provide materials used, or perform work required, to stabilize subgrade so it can withstand loads that may be placed upon it by Contractor's equipment.

B. Borrow area: There is no borrow area on Project site:
   1. Where material is required, import material from source located off Project site selected by the Contractor and subject to acceptance by the Engineer.

C. Compaction:
   1. Provide specified compaction for backfills, cuts, embankments, fills, roadway fills, and other earthwork.
   2. Perform confirmation tests to verify and confirm that work has complied, and is complying at all times, with compaction requirements specified in this Section for initial compaction demonstration and field quality control testing.
   3. In-place density of compacted backfills, cuts, embankments, fills, and roadway fills determined in accordance with ASTM D1556, or with ASTM D6938.
   4. Maximum density, laboratory compaction: Soil maximum density and optimum water content when tested in accordance with ASTM D1557.
   5. To prevent damage to structures due to backfilling operations, place backfill with equipment that does not exceed AASHTO Standard Specifications for Highway Bridges, H-20 vehicle loading, within a distance from the face of the structure of not less than 1/2 the depth of backfill. The depth of backfill is the distance between the level being compacted and the bottom of the
excavation. Outside this distance, heavier compaction equipment may be used.

6. Compact to percentage of maximum density as follows:
   a. Backfill adjacent to structures: 95 percent.
   b. Backfilling voids: 95 percent.
   c. Other areas: 90 percent.
   d. Under present structures: 95 percent.
   e. Under roadways, parking and storage areas, curbs, and sidewalks: 95 percent.
   f. Upper 6 inches of cuts: 90 percent.
   g. Fills: 90 percent.

D. Excavation:
   2. Excavations for trenching: As specified in Section 02318 - Trenching.
   3. Excavations for structures:
      a. Provide excavations conforming to dimensions and elevations indicated on the Drawings for each structure.
      b. After clearing is complete, excavate for the structure, down to the elevation indicated on the Drawings. Unless directed by Engineer, do not carry excavations below elevation indicated on the Drawings.
      c. Where soil is encountered having unsuitable bearing value, Engineer may direct in writing that excavation be carried to elevations below those indicated on the Drawings.
      d. Where excavations are made below elevations indicated on the Drawings, adjust elevations of excavations in accordance with the following requirements:
         1) Under slabs: Restore to proper elevation in accordance with procedure specified for backfill in this Section.
         2) Under footings: Restore to the proper elevation using one of the following:
            a) Aggregate base course.
            b) Controlled density fill.
      e. Excavation width:
         1) Extend excavations at least 2 feet clear from walls and foundations of structures to allow for placing and removal of forms, installation of services, and inspection.
         2) Do not undercut slopes.
      f. Difficulty of excavation: No extra compensation will be made for removal of rock or any other material due to difficulty of excavation.
   4. Necessary over excavation:
      a. Where it becomes necessary to excavate beyond normal lines of excavation in order to remove boulders or other interfering objects, backfill voids remaining after removal as specified in backfilling of voids below, or as acceptable to the Engineer.
b. Backfill voids with material acceptable to the Engineer:
   1) With acceptance of the Engineer, backfill with one of the following:
      a) Aggregate base course.
      b) Controlled density fill.

E. Materials for backfills, embankments, fills, and roadway fills:
   1. General:
      a. Obtain import material from other sources if surplus materials from cuts and excavations obtained from within Project site do not conform to specified requirements or are not sufficient in quantity for construction of Project.
   2. Backfills:
      a. Backfill adjacent to structures, slabs, or walls: Native material or imported material meeting the requirements of native material, unless otherwise specified or indicated on the Drawings.
      b. Backfill material under concrete structures: Aggregate base course material, except in areas where controlled density fill or concrete encasement are indicated on the Drawings.
      c. Extend backfill in any area under concrete structures from undisturbed soil or rock to the bottom aggregate base course material layer.
   3. Embankments:
      a. Native material or imported material meeting the requirements of native material, unless otherwise specified or indicated on the Drawings.
   4. Fills:
      a. Native material or imported material meeting the requirements of native material, unless otherwise specified or indicated on the Drawings.
      b. Extend fill in any area under concrete structures from undisturbed soil or rock to the bottom aggregate base course material layer.
   5. Roadway fills: One of the following, unless otherwise specified or indicated on the Drawings:
      a. Aggregate base course material.
      b. Native material or imported material meeting the requirements of native material.

F. Placement:
   1. General:
      a. Lines and grades:
         1) Construct backfills, embankments, fills, and road fills, at locations and to lines and grades indicated on the Drawings.
         2) Overbuild all permanent fill slopes by at least 1 foot and then cut to final grade to provide adequate compaction of the remaining fill.
      b. Place loose material in successive layers that do not exceed 8 inches in depth after compaction.
b. Bring each layer to a moisture content between optimum moisture content and 3 percent above optimum moisture content before compacting.
c. Defective compacted backfills: Remove and recompact.

3. Fills:
   a. Place loose material in successive layers that do not exceed 8 inches in depth after compaction.
   b. Bring each layer to a moisture content between optimum moisture content and 2 percent above optimum moisture content before compacting.
   c. Defective compacted fills: Remove and recompact.

4. Embankments:
   a. Place loose material in successive layers that do not exceed 8 inches in depth after compaction.
   b. Bring each layer to a moisture content between optimum moisture content and 3 percent above optimum moisture content before compacting.
   c. Defective compacted embankments: Remove and recompact.

5. Roadway fills:
   a. Place loose material in successive layers that do not exceed 8 inches in depth after compaction.
   b. Bring each layer to a moisture content between optimum moisture content and 3 percent above optimum moisture content before compacting.
   c. Defective compacted roadway fills: Remove and recompact.

3.04 FIELD QUALITY CONTROL

A. Tests:
   1. Confirmation tests:
      a. Contractor’s responsibilities:
         1) Costs of confirmation tests: Costs for all confirmation tests shall be as follows:
            a) All tests required either by the governing agency having jurisdiction over the right-of-way or by the District shall be performed by the District or its agent at District’s expense. However, in the event these tests prove the results to be unacceptable to either the governing agency or the District, all subsequent tests required by the governing agency or the District shall be performed by District at the Contractor’s expense. Tests will be scheduled within 24 hours of the Contractor’s request for tests, at locations to be selected by the District and/or the governing agency. However, tests shall not be scheduled until a minimum 4 hours work is available for the
testing laboratory, as determined by the Engineer. Results of these tests shall then be available within 48 hours.

2) Accomplish specified compaction for backfills, fills, and other earthwork.

3) Control operations by confirmation tests to verify that compaction work complies, and is complying at all times, with requirements specified in this Section concerning compaction, control, and testing.

b. Frequency of confirmation testing:
   1) In-place density:
      a) Backfill: One test every 250 cubic yards.
      b) Cuts: One test every 250 cubic yards.
      c) Embankments: One test every 250 cubic yards.
      d) Fills: One test every 250 cubic yards.
      e) Roadway Fills: One test every 250 cubic yards.

   2) Maximum dry density versus moisture:
      a) Backfill: One test of representative material.
      b) Cuts: One test of representative material.
      c) Embankments: One test of representative material.
      d) Fills: One test of representative material.
      e) Roadway Fills: One test of representative material.

B. Tolerances:
   1. Finish grading of backfills, cuts, embankments, fills, and roadway fills:
      a. Perform fine grading under concrete structures such that finish surfaces are never above the grade or cross section indicated on the Drawings and are never more than 0.10 feet below.
      b. Provide finish surface for areas outside of structures that are within 0.10 feet of grade or cross section indicated on the Drawings.

   2. Unlined channels and basins:
      a. In both cut and fill, and levee and access road side slopes in cut: Vertical tolerance of none above and 3 inches below grade indicated on the Drawings on bottom and side slopes.
      b. On top surface of levee and access road in both cut and fill, and levee and access road side slopes in fill: Vertical tolerance of none below and 3 inches above grade indicated on the Drawings.

   3. Areas which are not under structures, concrete, asphalt, roads, pavements, sidewalks, dikes, and similar facilities:
      a. Provide finish graded surfaces of either undisturbed soil, or cohesive material not less than 6 inches deep.
      b. Intent of proceeding is to avoid sandy or gravelly areas.

   4. Finish grading of surfaces:
      a. Reasonably smooth, compacted, and free from irregular surface changes.
      b. Provide degree of finish that is ordinarily obtainable from blade grader operations, except as otherwise specified.
      c. Uniformly grade areas that are not under concrete.
d. Finish ditches and gutters so that they drain readily.

3.05 ADJUSTING

A. Finish grades of excavations, backfills, and fills:
   1. Repair and reestablish grades to required elevations and slopes due to any settlement or erosion that may occur from action of the elements or any other cause prior to final acceptance.

3.06 PROTECTION

A. Finish grades of backfills, cuts, excavations, and fills:
   1. Protect newly graded areas from erosion and deterioration by action of the elements.

B. Ditches and gutters:
   1. Maintain ditches and gutters free from detrimental quantities of debris that might inhibit drainage until final acceptance.

END OF SECTION
PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Trench excavation and trench backfill.

1.02 REFERENCES

A. ASTM International (ASTM):
   2. D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

1.03 SUBMITTALS

A. As specified in General Conditions.

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

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

1.04 DEFINITIONS

A. Backfill: Material placed in trench above the pipe embedment zone.

B. Bedding: Material placed under, around, and over pipes or ducts in trenches.

C. Center bedding: Material placed at the bottom of the trench directly under the center of the pipe to provide a malleable resting surface.

D. Fine grading: Material placed directly below pipes or ducts to provide support at the bottom of the trench and to bring those elements to required grades and elevations.

E. Flexible pipe: Includes steel, ductile iron, thermoplastics such as polyvinyl chloride (PVC) and high-density polyethylene (HDPE), thermosetting plastics such as
fiberglass-reinforced polymer (FRP), bar-wrapped concrete cylinder pipe, and corrugated steel pipes.

F. Haunch zone: Material placed below and beside the pipe up to the pipe springline.

G. Lift: A layer of soil or aggregate material, measured before compaction.

H. Maximum density, laboratory compaction: Soil maximum density and optimum water content when tested in accordance with ASTM D1557.

I. Maximum density, field compaction: Soil density and water content when tested in accordance with ASTM D6938.

J. Pavement section: Includes pavement plus underlying courses such as base course and subgrade.

K. Pipe embedment zone: Includes bedding, fine grading, center bedding, and haunch zone.

L. Pipe foundation: Material placed at the bottom of trench to provide support.

M. Pipe springline: A horizontal reference line located at mid-height, or halfway point, of a circular conduit, pipe, or tunnel. It is the maximum horizontal dimension or diameter of a circular conduit, pipe, or tunnel.


PART 2 PRODUCTS

2.01 MATERIALS

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

B. Class C concrete: As specified in Section E03300 - Cast-in-Place Concrete.

C. Controlled low-strength material (CLSM): As specified in Section E02252 - Control Density Fill.

PART 3 EXECUTION

3.01 PREPARATION

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

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

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

C. Trench widths as specified in the following table:

<table>
<thead>
<tr>
<th>Buried Pipe Or Accessory</th>
<th>Minimum Trench Width</th>
<th>Maximum Trench Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal Pipe Diameter: 4 inch to 24 inch</td>
<td>OD + 18 inches</td>
<td>OD + 24 inches</td>
</tr>
<tr>
<td>Nominal Pipe Diameter: Greater than 24 inch</td>
<td>OD + 24 inches</td>
<td>OD + 36 inches</td>
</tr>
<tr>
<td>Manholes, valves, or other accessories</td>
<td>12 inches between outer surface and trench side or shoring</td>
<td>Not applicable</td>
</tr>
</tbody>
</table>

D. At road crossings or existing driveways:
   1. Make provision for channel or trench crossings at these points, either by means of trenchless technologies or temporary bridges.
   2. Engineer approval for remedy, without additional cost to District, when trench width at top of pipe is increased beyond width specified in this Section because of soil conditions, safety requirements, or other reasons:
      a. Remedy may include upgrade laying conditions or install stronger pipe designed in accordance with Specifications.

3.03 TRENCH BACKFILL - GENERAL

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

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

C. Backfilling of manhole excavation: Conform to backfilling requirements as specified for trenches in this Section.

3.04 PIPE FOUNDATION

A. Provide trench bottom with firm, dry, uniform bearing surface at the grade indicated on the Drawings:
   1. Prepare pipe foundation, including any unauthorized excess excavation below elevation indicated on the Drawings, at no additional cost to District.
B. If bottom of trench excavation consists of soil:
   1. Scarify bottom of trench to a depth of 6 inches below the grade indicated on the Drawings.
   2. Materials and placement:
      a. Recompact scarified material to 95 percent of maximum density.

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

D. If bottom of trench excavation consists of unacceptable material:
   1. Remove such unacceptable material to a depth of not less than 18 inches below pipe embedment zone.
   2. Material and placement up to embedment zone:
      a. Aggregate base course material compacted to 95 percent of maximum density:
         1) Maximum particle size for backfill material limited as specified in the following table:

<table>
<thead>
<tr>
<th>Buried Pipe</th>
<th>Maximum Particle Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal Pipe Diameter: 6 inch to 8 inch</td>
<td>3/4 inch</td>
</tr>
<tr>
<td>Nominal Pipe Diameter: 10 inch to 16 inch</td>
<td>1 inch</td>
</tr>
<tr>
<td>Nominal Pipe Diameter: Greater than 18 inch</td>
<td>1 1/2 inches</td>
</tr>
</tbody>
</table>

3.05 Pipe Embedment Zone

A. General:
   1. Pipe displacement:
      a. Take necessary precautions in placement and compaction of bedding material to prevent displacement of piping.
      b. In event there is movement or floating of the piping, re-excavate, re-lay, and backfill the pipe.
   2. Depressions for joints or couplings:
      a. Excavate holes in graded trench bottom.
      b. Provide holes of sufficient width to provide ample room for grouting, banding, or welding as necessary for making joints and to ensure that pipe rests upon prepared trench bottom and not supported by any portion of the joint.
B. Rigid pipe:
   1. Fine grading:
      a. Compacted depth below bottom of pipe: 6-inch minimum.
      b. Materials and placement:
         1) Aggregate base course compacted to 95 percent maximum dry density.
   2. Bedding:
      a. Compacted depth above top of pipe: 12 inch minimum.
      b. Materials and placement:
         1) Aggregate base course compacted to 95 percent maximum dry density.

C. Flexible pipe:
   1. Center bedding:
      a. Compacted depth below bottom of pipe: 12-inch minimum.
      b. Compacted width below bottom of pipe: Trench width.
      c. Materials and placement:
         1) Uncompacted sand at uniform density, minimize compaction.
   2. Haunch zone:
      a. Materials and placement:
         1) Aggregate base course compacted to 95 percent maximum dry density.
         2) CLSM.
   3. Bedding:
      a. Compacted depth above top of pipe: 12-inch minimum.
      b. Materials and placement:
         1) Aggregate base course compacted to 95 percent maximum dry density.
         2) CLSM.

3.06 Backfill

A. Trenches:
   1. Materials and placement:
      a. Native soil compacted to 95 percent maximum dry density.
      b. Imported fill compacted to 95 percent maximum dry density.
      c. Aggregate base course compacted to 95 percent maximum dry density.
      d. CLSM.

B. Trenches in rock:
   1. Backfill to top of rock:
      a. Materials and placement:
         1) CLSM.
         2) Class C concrete.
2. Backfill from top of rock to grade, if applicable:
   a. Materials and placement:
      1) Aggregate base course compacted to 95 percent of maximum density.

C. Trenches below or within 10 feet of the outside perimeter of structures:
   1. Backfill to underside of aggregate base course below structure.
   2. Materials and placement:
      a. Aggregate base course compacted to 95 percent of maximum density.
      b. CLSM.

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

E. Trenches in areas outside the improved section of roadways or in open country:
   1. Backfill to finished grade.
   2. Materials and placement:
      a. Native soil, native soil - select, imported material, or aggregate base course compacted to 90 percent of maximum density.

F. Trenches under existing intersecting pipes, duct banks, or conduits larger than 3 inches in diameter:
   1. Backfill from above top of new pipe embedment zone to springline of intersecting pipe or conduit:
      a. Extend backfill at least 2 feet on either side of intersecting pipe or conduit to ensure backfill material remains in place while other backfill is being placed.
      b. Materials and placement:
         1) CLSM, unless otherwise indicated on the Drawings.
   2. Backfill remainder of trench:
      a. Materials and placement:
         1) CLSM.
         2) Class C concrete.

3.07 EXCESS MATERIAL

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

3.08 FIELD QUALITY CONTROL

A. Provide field quality control for the Work as specified in Section 01450 - Quality Control.
B. Confirmation tests: As specified in Section 02300 - Earthwork:
   1. Minimum frequency of confirmation testing:
      a. At each test location include tests for each type or class of backfill from
         bedding to finished grade.
      b. For trenches: 1 location every 200 linear feet.
      c. In open fields: 2 locations every 1,000 linear feet or 1 location every
         200 cubic yards.
      d. Crossing paved roads: 1 location at each crossing.
      e. Under pavement cuts or within 2 feet of pavement edges: 1 location
         every 400 linear feet.

C. Piping system testing:
   1. As specified in Section 15956 - Piping Systems Testing.

END OF SECTION
SECTION 02370
RIPRAP AND GABIONS EROSION AND SEDIMENTATION CONTROL

PART 1   GENERAL

1.01   SUMMARY

A.   Section includes: Grouted riprap.

1.02   REFERENCES

A.   ASTM International (ASTM):

1.03   SUBMITTALS

A.   Product data.

B.   Installation instructions.

PART 2   PRODUCTS

2.01   GROUTED RIPRAP

A.   Material: Rock, 1/8 to 1 cubic foot, 20 to 150 pounds.

B.   Size and weight: 1/8 cubic to 1 cubic foot and 20 to 150 pounds, except small stones and spalls used to chink interstices shall weigh not less than 10 pounds and at least 50 percent of pieces shall weigh not less than 100 pounds.

C.   Material shapes:
     1.   Capable of forming stable protection structure of required depth.
     2.   Angular.
     3.   Flat or needle shapes with thickness more than 1/3 length.

D.   Cement: In accordance with ASTM C150, Type II.

E.   Aggregate:

F.   Water: Clean.
G. Grout mix:
   1. Hand mix when acceptable to the Engineer or machine mix. 1 part cement, 2 parts fine aggregate, and 1 part coarse aggregate by volume, with water as required and acceptable to the Engineer to permit gravity flow of grout into interstices with limited spading and brooming.
   2. When hand mixing, thoroughly mix cement and aggregate in clean, tight mortar box until mixture is of uniform color, then add water in such quantity as to provide a grout of specified consistency.
   3. When machine mixing, mix in accepted machine for not less than 1-1/2 minutes.

PART 3 EXECUTION

3.01 PREPARATION

   A. Shape and trim bed for riprap as required to provide even surface which at no point is higher than design surface.
   B. Excavate footing trench along toe and cutoff trench at top of slope, as indicated on the Drawings.

3.02 PLACING GROUTED RIPRAP

   A. Place material in manner to provide minimum of voids.
   B. Place larger pieces in toe trench, foundation course, and on outer surface of riprap.
   C. Place pieces with their longitudinal axis normal to face of embankment and so arranged that each piece above foundation course has at least a 3-point bearing on underlying material:
   1. Fill interstices between pieces with small pieces and spalls. Bearing on smaller pieces used to fill voids will not be acceptable.
   D. Grout with grout mix specified for grouted riprap.

3.03 TOLERANCES

   A. Finished surfaces of riprap for grouted riprap: Within 3 inches per foot of depth.

END OF SECTION
PART 1  GENERAL

1.01  SUMMARY

A. Design, fabricate, and install precast electrical handholes and precast electrical manholes of the size and type indicated on the Drawings and specified:
   1. Construction of cast-in-place concrete electrical structures, including handholes and manholes, are specified in other sections.

B. Section includes:
   1. Precast portland cement concrete handholes and accessories.

C. Alternates:
   1. Contractor may propose to construct cast-in-place structures in lieu of the precast structures specified:
      a. Obtain Engineer’s acceptance of this alternative before submitting, providing, or installing.
      b. Submit full information on design and detailing of proposed alternatives including design details and drawings of the same types required by this Section for precast structures.

1.02  REFERENCES

A. American Association of State Highway Transportation Officials (AASHTO):

B. American Concrete Institute (ACI):
   1. 318 - Building Code Requirements for Structural Concrete and Commentary.

C. ASTM International (ASTM):

D. National Fire Protection Association (NFPA):

E. National Precast Concrete Association (NPCA).

F. Society of Cable Telecommunications Engineers (SCTE):
   1. 77 - Specification for Underground Enclosure Integrity.

G. Underwriters Laboratories (UL).

1.03 DEFINITIONS

A. Handhole: An enclosure for use in underground systems that has been sized and detailed to allow personnel to reach into, but not enter, the enclosure to install, operate, or maintain equipment or wiring or both. (Reference: NEC, Article 100):
   1. As used in this Section, “handhole” will refer to a precast electrical handhole.

B. Manhole: An enclosure for use in underground systems that has been sized and detailed to allow personnel to enter the enclosure to install, operate, or maintain equipment or wiring or both:
   1. As used in this Section, “manhole” will refer to a precast electrical manhole.

C. Portland cement concrete: A composite material consisting of a portland cement binder, water, admixtures, and a combination of fine and coarse mineral aggregates:
   1. Abbreviated “PCC” as in “PCC HANDHOLE” or “PCC MANHOLE.”

D. Precast concrete: A concrete fabrication designed by a qualified engineer and subsequently fabricated at a qualified fabrication site, which is usually located some distance from the site where the fabrication will be installed.

1.04 SYSTEM DESCRIPTION

A. General requirements for handholes and manholes:
   1. As specified in Section 16050 - Common Work Results for Electrical for general requirements for electrical work.
   2. Provide structures of the sizes and shapes indicated on the Drawings, with layouts, dimensions, and details as indicated on the Drawings and as specified.
   3. Conform to the requirements of:
      a. NEC.
      b. Project regulatory requirements as specified in Section 01410 - Regulatory Requirements.
B. Portland cement concrete handholes and manholes:
   1. Load resistance of boxes and covers.
   2. Design requirements: Loads on structures:
      a. In accordance with ASTM C857, except as modified in this Section.
      b. Loads at the ground surface:
         1) See “Electrical Handhole and Manhole Schedule” indicated on the
            Drawings for minimum surface loading requirements at each
            structure. Loads are designated as “sidewalk,” or “roadway”.
         2) The vehicle and pedestrian loadings in the following paragraphs
            need not be additive; however, structures designated for “roadway”
            loading shall also support “sidewalk” loads.
         3) “Sidewalk”: Load from regular pedestrian traffic with considerations
            for occasional non-deliberate vehicular traffic:
            a) Designation "A-0.3" in ASTM C857 Table 1 (300-psf uniform
               load).
         4) “Roadway”: Load from heavy, frequently repeated vehicle traffic:
            a) Designation "as specified in Table 1.
      c. Lateral earth pressure loads:
         1) Determine in accordance with the following requirements. Include
            effects of groundwater and seismic accelerations on lateral earth
            pressures:
            a) Equivalent lateral pressure: 40 pounds per square foot per foot
               of depth (triangular distribution).
            b) Surface surcharge load:
               (1) Backfill-induced live load surcharge of 90 pounds per
                   square foot (rectangular distribution).
               (2) In accordance with ASTM C857 Vehicle Load Designation
                   "A-16" for "Roadway" or "A-0.3" for "Sidewalk" where such
                   surcharge exceeds backfill loads described in the preceding
                   paragraph.
            c) Seismic acceleration effects:
               (1) As specified in Section 01610 - Project Design Criteria and
                   Section 01612 - Seismic Design Criteria.
               (2) Apply seismic effects as additive force on side where the
                   soil mass is being accelerated toward the structure, and as
                   subtractive force on the opposite side where the soil mass
                   is being accelerated away from the structure.
      d. Groundwater and flood loads - buoyancy effects:
         1) As specified in Section 01610 - Project Design Criteria for design
            groundwater and design flood elevations.
         2) Buoyancy: For groundwater and flood conditions, provide factor of
            safety against flotation of at least 1.20:
            a) If the weight of soil overlying footing projections on the
               structure is considered to resist flotation, use a buoyant unit
               weight of soil equal to not more than 30 pounds per cubic foot.
b) Concrete fill may be provided in the bottom section of precast portland cement concrete structures to add weight. Submit proposed details.

e. Soil-bearing pressure at base:
   1) Maximum 2,500 pounds per square foot total pressure on prepared subgrade soils.

f. Lifting and handling loads:
   1) Make provision in the design for the effects of loads or stresses that may be imposed on structures during fabrication, transportation, or erection.

g. Load combinations:
   1) Design structures to sustain the specified loads individually or in combination.

3. Design requirements: Structural analysis, design, and detailing:
   a. General:
      1) Analyze and design structures including the effects of 2-way action ("plate action") and of load transfer around current and future openings.
      2) Where structures include panels designed for future removal ("knockout panels"), design structures for loads and stresses with any combination of any or all such panels in place or removed.

   b. Precast portland cement concrete handholes and manholes:
      1) Design structures in accordance with the requirements of ACI 318 and this Section.
      2) Provide reinforcement at all areas subject to tensile stress when loaded with the specified loads and combinations thereof.
      3) Provide temperature and shrinkage reinforcement to equal or exceed ACI 318 requirements in all concrete sections.
      4) Provide minimum clear concrete cover over reinforcement at both interior and exterior faces of all members in accordance with the following:
         a) Handholes: 1.25 inches.
         b) Manholes: 2 inches.
      5) Reinforcement details:
         a) Walls: For structures with wall thickness of 8 inches or less, locate a single mat of reinforcement at the center of the wall.
         b) Slabs: For structures with slab thickness of 7 inches or less, locate a single mat of reinforcement at the center of the slab.
         c) Structures with wall or slab thicknesses exceeding these limits shall have a reinforcement at each face of the member.

   6) Joints:
      a) Provide structures with watertight joints between sections, and detailed to minimize water infiltration at duct bank and conduit penetrations.
b) Provide structures with non-skid, shiplap or tongue and groove joints between sections.

4. Design requirements: Materials:
   a. Portland cement concrete handholes and manholes:
      1) In accordance with ASTM C858.

1.05 SUBMITTALS

A. Product data: Manufacturer’s catalog data, details, and warranties for the following items:
   1. Polymer concrete handholes:
      a. Materials of construction, and resistance of those materials to water absorption, flammability, sunlight/ultraviolet exposure, and chemicals likely to be found in the area of use.
      b. Available colors.
      c. Details for covers, cover support, and cover attachment to the underlying box.
   2. Portland cement concrete handholes and manholes:
      b. Joint details and joint-sealing materials.
      c. Data for hatches or covers and rings.
      d. Preformed channels and accessories for cable racking.
      e. Drain and sump details, including removable covers.
      f. Pulling iron details.

B. Shop drawings:
   1. Polymer concrete handholes:
      a. Manufacturer’s catalog cuts showing dimensions and details of construction.
   2. Portland cement concrete handholes and manholes:
      a. Shop drawings for each structure shall bear the seal and signature of a structural engineer licensed in the state of California.
      b. Dimensioned and “to-scale” plans, sections, and details for each structure including:
         1) Layout plan for that structure.
         2) Sizes, locations, and vertical positions of duct bank windows and knockout panels.
         3) Locations and details for access openings, pulling irons, embedded cable supports and racks, and sumps.
         4) Details of structural reinforcement showing bar size and spacing; true position of reinforcement in structural members with clear concrete cover at both inside and outside faces; location, bar size, and spacing of added reinforcement around openings; and other details relevant to design and fabrication of the structure.
         5) Details of joints between adjacent precast sections, including provisions for overlap and for placement of sealants.
C. Design data:
   1. Portland cement concrete handholes and manholes:
      a. Structural calculations:
         1) Submit complete structural calculations for each structure.
         2) Provide calculations bearing the seal and signature of a structural engineer licensed in the state of California.
      b. Manufacturer’s statement of materials used for fabrication and construction, in accordance with ASTM C858, for record. Include the following:
         1) Concrete mix design: For each concrete mix design to be used for the structures, include data describing:
            a) Source and type of cement.
            b) Sources, grading, and specific gravities of aggregates.
            c) Aggregate reactivity data.
            d) Concrete mix proportions and design strength.
            e) Type, name, and dosage of all admixtures included in the concrete mix.
         2) Reinforcing steel: Mill certificates.

D. Test reports:
   1. Polymer concrete handholes:
      a. Independent laboratory test reports bearing the seal of a licensed professional engineer and demonstrating compliance with the requirements of SCTE 77 for the loading conditions specified.
   2. Portland cement concrete handholes and manholes:
      a. Fabricator’s tests for compressive strength of concrete used in structures, made in accordance with recommendations of ASTM C858.

E. Certificates:
   1. Polymer concrete handholes:
      a. Manufacturer’s certification that polymer concrete handholes are in accordance with the requirements of SCTE 77.
   2. Portland cement concrete handholes and manholes:
      a. Manufacturer’s current plant certification under NPCA for the structures to be supplied:
         1) Certification shall be current and in-effect at the time structures are manufactured.
      b. Manufacturer’s certification that handholes and manholes are in accordance with the requirements of ASTM C858.

F. Manufacturer’s instructions:
   1. Instructions for handling and setting structures in place.
   2. Portland cement concrete handholes and manholes:
      a. Instructions for operation and maintenance of hatches.
G. Manufacturer’s field reports:
   1. Portland cement concrete handholes and manholes:
      a. Manufacturer’s inspection reports in accordance with ASTM C1037.

H. Closeout documents:
   1. Project record documents:
      a. Portland cement concrete handholes and manholes:
         1) Final, revised plans and details of as-constructed precast handholes and manholes if requested for record by the Engineer.
   2. Warranties:
      a. Manufacturer’s standard warranty for:
         1) Polymer concrete handholes.
         2) Portland concrete handholes and manholes and accessories.

1.06 QUALITY ASSURANCE

A. Qualifications:
   1. Designer:
      a. Portland cement concrete handholes and manholes:
         1) Structural engineer qualified in the design of concrete structures and holding a current license in the state of California.
   2. Manufacturer:
      a. Polymer concrete handholes:
         1) Demonstrating at least 5 years of experience in the design and production of products of the type required for this Work.
         2) Holding product testing records demonstrating load resistance of products to be installed.
      b. Portland cement concrete handholes and manholes:
         1) Holding current NPCA plant certification for the products produced.
         2) Demonstrating at least 5 years of experience in the design, production, and installation of products of the type required for this Work.
         3) Capable of providing structural designs prepared by a structural engineer licensed in the state of California.
         4) Providing inspection during fabrication and handling in accordance with the requirements of ASTM C1037.
   3. Installer:
      a. Capable of providing equipment of adequate capacity and mobility to handle and set units with proper bearing on the subgrade and without damage to the unit.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Packing, shipping, handling, and unloading:
   1. Package and brace structures to avoid damage during shipping and handling.
2. Furnish crane or forklift for unloading and setting of portland cement concrete handholes and manholes.

B. Acceptance at site:
   1. Structures delivered to the site with cracks, damage, and damaged or missing accessories shall be removed from the site and replaced at no additional cost to the District.

C. Storage and protection:
   1. Store handholes and manholes and their appurtenances in areas protected from damage due to weather and site operations.
   2. Portland cement handholes and manholes.

1.08 PROJECT SITE CONDITIONS

A. Environmental requirements: As specified in Section 01610 - Project Design Criteria.

1.09 SEQUENCING

A. Coordinate installation of precast electrical handholes and manholes with duct banks specified in Section 16133 - Duct Banks.

1.10 WARRANTY

A. Provide manufacturer’s standard warranty for precast handhole and manhole structures and accessories.

1.11 SYSTEM START-UP

A. As specified in Section 16050 - Common Work Results for Electrical.

PART 2 PRODUCTS

2.01 EXISTING PRODUCTS

A. Portland cement concrete handholes and manholes.

2.02 SOURCE QUALITY CONTROL

A. Portland cement concrete handholes and manholes.

2.03 MANUFACTURED UNITS - POLYMER CONCRETE HANDHOLES

A. General:
   1. Enclosures, boxes, and cover shall conform to all test provisions of SCTE 77.
B. Manufacturers: One of the following or equal:
   1. Quazite Division of Hubble, Incorp.
   2. Carson Ind., LLC.

C. Materials:
   1. Polymer concrete with optional fiberglass reinforcement:
      a. Handholes constructed of plastic or fiberglass will not be permitted.

D. Components:
   1. Cover:
      a. Provide gasketed cover with lifting slot and stainless steel hex head bolts for attachment to box.
      b. Fasten cover to box using stainless steel hex head bolts.
      c. Skid-resistant surface: Coefficient of friction for walking surface on top of cover shall be at least 0.50 when measured in accordance with ASTM C1028.
      d. Custom logo not required.
   2. Box:
      a. Open-bottom base unless otherwise indicated on the Drawings:
         1) Stackable sections with interlocking joints to maintain horizontal and vertical alignment.
      b. Provide knockouts, terminators, pulling eyes, and inserts as required for a complete installation.
   3. Fabrication:
      a. All components in assembly (boxes and cover) shall be manufactured using matched surface tooling for consistency of production.

E. Load rating:
   1. Provide “TIER” rating based on Schedule of Electrical Handholes and Electrical Manholes indicated on the Drawings, and the following loading requirements:

<table>
<thead>
<tr>
<th>Surface Loading Rating</th>
<th>Requirements</th>
</tr>
</thead>
</table>
   | “Sidewalk”             | “TIER 15” - “Medium Duty”  
For driveway, parking, and ramp areas where vehicle wheel loads will not exceed 2,000 pounds on a single wheel. |
   | “Roadway”             | Not allowed. - “Heavy Duty”  
For highway traffic or AASHTO wheel loads of at least 16,000 pounds. |

   2. Provide covers with “TIER” rating embossed or cast into the top surface.
   3. Design load rating of cover for an assembly may not exceed the design load rating of the box below.

F. Accessories:
   1. Provide 2 non-corroding steel lifting hooks for removing covers.
2.04 MANUFACTURED UNITS - PORTLAND CEMENT CONCRETE HANDHOLES AND MANHOLES

A. General:
   1. Provide portland cement concrete handholes and manholes configured and designed as indicated on the Drawings and specified.
   2. In accordance with ASTM C858 unless otherwise noted:
      a. Concrete: Provide units with minimum specified compressive strength \( f'c \) of 4,000 pounds per square inch.

B. Manufacturers: One of the following, or equal:
   1. Oldcastle Precast.
   2. Jensen Precast.

C. Components:
   1. Floor:
      a. Construct floors as a monolith.
      b. Where sump or low-point drain is included, slope floor to that point.
   2. Roof, walls, and base:
      a. Designed and rated to support vehicle and pedestrian loads at the spans indicated.
      b. See the Electrical Handhole and Manhole Schedule indicated on the Drawings for required load rating by structure location.
   3. Access covers:
      a. Handholes: Aluminum plate hinged floor access door (hatch):
         1) Load rating:
            a) “Heavy Duty” for covers at locations designated for “Roadway” loads.
            b) “Medium Duty” or stronger for covers at locations designated for “Sidewalk” loads.
         2) Minimum access door size not less than 36 inches square, unless otherwise indicated on the Drawings.
         3) Provide bearing surface with pre-installed continuous elastomeric gasket to minimize water infiltration at lid.
         4) Provide skid-resistant lid with cast-in or machined-in grid pattern and the word “ELECTRICAL” in block letters at least 1.5 inches high.

D. Accessories:
   1. Provide accessories as indicated on the Drawings and specified.
   2. Materials at duct bank penetrations:
      a. Joint filler as specified in Section 03150 - Concrete Accessories.
      b. Backer rod and sealant as specified in Section 07900 - Joint Sealants.
   3. Pulling irons:
      a. Provide non-corroding cable pulling irons located for use with each current duct bank location and additional irons for use with duct banks that may be installed through future knockout panels.
b. Pulling irons may not be located on the floor.
c. Where pulling irons are installed on the wall, any pockets surrounding the irons shall have bottom surfaces sloped to drain.
d. Secure pulling eyes to structure reinforcement.

4. Cable racks and racking hardware:
   b. Embedded slots: Maximum depth of 1.5 inches.

5. Sumps and drains:
   a. Fiberglass or HDPE fabrications including removable lids to prevent tripping hazards.

6. Exterior dampproofing:
   a. Field applied to all wall and roof surfaces exposed to soil.

E. Fabrication:
   1. Embeds:
      a. Install embedded items with provisions for drainage to remove dripping or standing water, and to minimize corrosion:
         1) Pulling irons may not be placed on the floor or in pockets that will collect water.
         2) Detail bottom of cable rack channels to provide a downward sloping “sill” at the bottom of each vertical channel, so that the channel slot drains toward the floor.
      b. Concrete cover:
         1) Provide minimum 0.75-inch clear concrete cover between embeds and surrounding reinforcement.
         2) Provide minimum 1.25-inch clear concrete cover between embed and exterior face of wall.

F. Tests and inspections:
   1. Test and inspect structures in accordance with ASTM C858 and ASTM C1037.

PART 3  EXECUTION

3.01 GENERAL

A. Furnish and install precast electrical handholes and manholes as indicated on the Drawings and specified.

B. Install additional handholes and manholes required so installation procedures will conform to cable manufacturer’s pulling tension requirements:
   1. Include proposed locations and details of such additional handholes and manholes with the submittals under this Section.
3.02 PREPARATION

A. Design:
   1. Prepare detailed and scalable layouts for each manhole structure showing locations of conduit or duct bank penetrations, clearances, locations, and sizes of access openings and major accessories.

B. Protection:
   1. Where handhole and manhole structures are installed adjacent to existing site structures or utilities, provide excavation support or other protection as required to maintain those facilities in service and to prevent damage to both existing and new facilities.

C. Site preparation:
   1. Excavate and prepare exposed subgrade as indicated on the Drawings and as specified.
   2. Install and compact foundation layer as indicated on the Drawings and specified.
   3. Level foundation materials so that structures will be set plumb, and duct banks will be at proper grade and alignment:
      a. Install with uniform bearing on foundation materials.
      b. Wedging or blocking of base sections for leveling over the foundation materials will not be permitted.

3.03 INSTALLATION

A. General:
   1. Protect handholes and manholes from displacement, flooding, or flotation.

B. Polymer concrete handholes:
   1. Install structures in accordance with the manufacturer’s recommendations.
   2. Clean joints between adjacent sections for tight fit.
   3. Set covers at elevations indicated on the Drawings:
      a. Securely attach cover to below-grade box.
   4. Backfill polymer concrete handholes as indicated on the Drawings and as specified.

C. Portland cement concrete handholes and manholes:
   1. Install structures in accordance with ASTM C891 and the provisions of this Section:
      a. In the event of conflicts, the more restrictive provisions shall apply.
   2. Clean and prime joints between adjacent precast sections:
      a. Install sealing compound between sections and provide watertight joints.
   3. Set covers and hatches at elevations indicated on the Drawings:
      a. Securely attach frames to top of precast structures and grade adjustment rings.
4. Penetrations:
   a. Holes for duct banks and other penetrations may not be cut into precast handholes and manholes unless they are located at designated locations shown on the shop drawings or at knockout panels cast into the structure during manufacturing.
   b. Carefully remove concrete from knockout panel areas with saws:
      1) Ensure that break-back does not extend beyond the designated limits of the knockout panel.
   c. Coat any reinforcement cut or exposed during removal of knockout panel sections with minimum 2 coats of high solids epoxy as specified in Section 09960 - High-Performance Coatings:
      1) Apply epoxy coating applied over and at least 1-inch past the perimeter of the reinforcement.

5. Install duct banks and conduit penetrations in accordance with the penetration details indicated on the Drawings:
   a. Place all joint fillers, caulks, and sealants before coating exterior concrete surface with bituminous dampproofing.

6. Fill holes that were provided for handling or other temporary purposes with non-shrink cement grout using procedures as specified in Section E03300 - Cast-in-Place Concrete unless otherwise detailed by the manufacturer.

7. After structures are set and before backfilling, coat exterior below-grade surfaces (around the sidewalls, over the top slab, and around any vertical risers to grade) with 2 heavy coats of bituminous dampproofing:
   a. Apply dampproofing in accordance with the coating manufacturer’s instructions and at a rate of 40 to 60 square feet per gallon per coat.
   b. Mask over at least 1 inch back from joint caulks or sealants, and prevent dampproofing from coming in contact with those materials.

8. Backfill handholes and manholes as indicated on the Drawings and as specified.

D. Site tolerances:
   1. Set electrical handholes and manholes plumb and true at locations indicated on the Drawings.
   2. Tolerances on placing:
      a. Horizontal location: Plus or minus 1 inch.
      b. Vertical elevation: Plus or minus 1/2 inch.
      c. Plumb: Plus or minus 1/8 inch over 10 feet.

3.04 REPAIR/RESTORATION

A. Repair cracks or blemishes in concrete as described in Section E03300 - Cast-in-Place Concrete by methods acceptable to the Engineer. Submit proposed repairs for acceptance before commencing work.
3.05 ADJUSTING

A. After final grading is complete, adjust access covers to grade.

3.06 CLEANING

A. Before installation of cables in any duct banks and handholes or manholes, remove all concrete spoil, forms, debris, silt, dust, and other foreign material.

3.07 SCHEDULES

A. See Drawings for Electrical Handhole and Electrical Manhole Schedule.

END OF SECTION
SECTION 02600

CONCRETE MANHOLES

PART 1  GENERAL

1.01  SUMMARY

A. Section includes:
   1. Manhole frames and covers.
   2. Manhole grade rings.
   3. Manholes cones and risers.
   4. Manhole bases.

1.02  REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO).

B. ASTM International (ASTM):
   8. C1244 - Standard Test Method for Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test Prior to Backfill.

C. International Organization of Standardization (ISO):
   1. 9001 - Quality Management Standard.

1.03  SUBMITTALS

A. Submit as specified in General Conditions.

B. Shop drawings:
   1. Manufacturer’s catalog data and details of following items for approval:
      a. Frame and covers.
      b. Grade rings.
c. Manhole cones and risers.
d. Manhole bases, if precast.
e. Reinforcing steel size and placement, including at openings and penetrations.

2. Manhole construction details, jointing methods, connection details, materials, and dimensions.

3. Repair procedures and details.

C. Calculations and criteria used in manhole design including material properties, loadings, load combinations, and dimensions assumed.

D. Test methods and results including certification that the manhole riser exceeds the minimum requirements in accordance with ASTM C478.

E. Sealed drawings and design calculations by a licensed Professional Engineer licensed in the State where the project is located.

F. Certificates
   1. ISO 9001 certificate by a third party confirming that ASTM test reports are valid and up to date at the time of the bid and during construction period.

1.04 PRODUCT REQUIREMENTS

A. As specified in Section 01600 - Product Requirements.

B. Provide suitable quantities of lifting equipment to handle the manholes/risers and castings.
   1. In no case shall any equipment be used that is not rated to handle the intended loading or conditions of use to which it will be subjected, or which will damage or gouge the manhole components.
   2. Dragging or dropping the manhole components shall not be allowed.

C. Source testing.
   1. Perform pre-production and post-production tests by manufacturer staff with a minimum of 5 years of experience in quality control, inspection, and testing of manholes.
      a. In lieu of this experience, witness of tests by up to 3 full-time District representatives.
   2. Examine each completed manhole section for dimensional requirements, strength, and workmanship.
   3. Complete required testing in accordance with ASTM C478.
   4. Provide the Manufacturer’s Certificate of Source Testing.

1.05 DESIGN CRITERIA:

A. Manholes shall not include steps.
B. Manhole lids: Locking type.

C. Manhole bases:
   1. Constructed as part of the pipe installation or using tee risers.

D. Manhole riser:
   1. Made of the same pipe material selected for the project, providing a sealed connection between the pipe base and riser as indicated on the Drawings.
   2. Manufactured specifically for this project and no materials shall be furnished from stock unless approved by the Engineer.

E. Manhole provider shall coordinate with the pipe manufacturer for dimensions and connections.

F. Manhole systems:
   1. Provided by a single manufacturer.

G. Frames and covers:
   1. Provided by a single manufacturer unless approved by the Engineer.

1.06 WARRANTY

A. As specified in General Conditions.

PART 2  PRODUCTS

2.01 MANUFACTURERS

A. Manhole grade rings, cones, and risers: One of the following or equal.
   1. Jensen Precast.
   2. Oldcastle.

B. Manhole frames and covers: Manufacturers: One of the following or equal.
   1. Alhambra Foundry Company.

2.02 BASIS OF DESIGN

A. Design in accordance with local jurisdiction requirements, including but not limited to the following:
   1. Manhole frames and covers.
   2. Manhole diameter tolerance.
   3. Manhole length.
   4. Manhole cover bolting.
   5. Manhole backfill.
B. Structural design calculations:
   1. Load rating of manhole:
      a. Design to support an AASHTO Standard Specifications for Highway Bridges, H-20 vehicle loading.
   2. Resist buoyancy:
      a. Design with sufficient bottom anchorage and side friction to resist buoyancy.
      b. Depths will be as indicated on the Drawings.
      c. Refer to the geotechnical report for soil condition including fully saturated soil conditions.

C. Manholes, grade rings, risers, and bases:
   1. Manhole:
      a. Nominal sizes as indicated on the Drawings.
   2. Grade rings:
      a. At least 1 but not more than 2 grade rings shall be used.
      b. Maximum total distance from top of cone section to final grade: 18 inches.
   3. Cone and riser sections:
      a. As specified in this Section and as indicated on the Drawings.
      b. Cone sections shall be concentric.
   4. Manhole bases:
      a. As specified in this Section and as indicated on the Drawings.
      b. Provide corrosion protection system on unlined concrete.

D. Threaded lifting inserts:
   1. Design inserts to be fully threaded:
      a. Do not fully penetrate through entire manhole wall.
   2. Provide lifting device compatible with spreader bar and chains, hooks and slings.
   3. Design with minimum safety factor of 4.0.
   4. Do not use reinforcing steel bars.

2.03 MATERIALS

A. Cast iron manhole frames and covers.
   1. In accordance with ASTM A48.
   2. Covers: Bolted as specified.
   3. Concrete collars: As indicated on the Drawings.
   4. Openings: Not less than 30 inches.

B. Manhole bases, risers, and grade rings:
   1. Cement: Type II portland cement in accordance with ASTM C150.
   2. Concrete aggregates: In accordance with ASTM C33, gradation as specified in approved mix design.
4. Precast concrete sections: Manufactured by a process that will produce a dense, homogeneous concrete ring.
5. Top and bottom of sections: Parallel.

C. Joint sealant:
   1. Preformed, cold applied flexible joint sealant in accordance with ASTM C990 and ASTM C443.
   2. Manufacturers: One of the following or equal.
      b. Kent Seal - Hamilton Kent Corp.

2.04 COMPONENTS

A. Pipe stubs:
   1. Provide pipe stubs at manhole locations and in accordance with details indicated on the Drawings and as specified.
   2. Plugging stubs:
      a. Plug stubs with vitrified clay stopper, brick plug, or other materials as indicated on the Drawings.
      b. Unless otherwise indicated on the Drawings, comply with following:
         1) Stubs up to and including 21 inches: Vitrified clay stoppers.
         2) Stubs greater than 21 inches: Brick plugs.

B. Resilient pipe connectors:
   1. Unless otherwise indicated on the Drawings or specified, provide a flexible compression type connector between manhole and pipes entering and leaving the manhole in accordance with ASTM C923.
   2. Resilient pipe connectors:
      a. Manufacturers: The following or equal.
         1) A-LOK Premium.

C. Threaded lifting inserts.

D. Drop manholes:
   1. Construct drop manholes at locations and in accordance with details indicated on the Drawings.
   2. Provide inside diameter of drop inlet pipe the same as intercepted sewer unless otherwise indicated on the Drawings or specified in this Section.
   3. Furnish and set fittings as indicated on the Drawings

2.05 IDENTIFICATION MARKINGS

A. Identification marks on the exterior of bases, risers, grade rings, and include the following information:
   1. Date of manufacture of the item.
   2. Name or trademark of the manufacturer.
3. Internal diameter in inches.
4. Number of the manhole as indicated on the Drawings.

2.06 Quality Control

A. Manufacturer to provide permanent quality control department and laboratory facility capable of performing inspections and testing as specified by this Section.

B. Material testing, inspection procedures, and manufacturing process are subject to inspection by the District or District’s representative.

C. Perform manufacturer's tests and inspections in accordance with the referenced standards and as specified in this Section including the following:
   1. Provide the Manufacturer's Certificate of Source Testing as specified in Section 01600 - Product Requirements.
   2. Manufacturer shall make available services of representative throughout the project duration when deemed necessary by the Engineer.
   3. Calibrate within last 12 months for equipment such as scales, measuring devices and calibration tools used in the manufacturing of pipe.
      a. Each device used in the manufacture of manholes is required to have a tag recording date of last calibration.
      b. Devices are subject to inspection by Engineer.

D. Furnish labor necessary to assist the Engineer in inspecting manholes upon delivery.

E. Remove rejected manholes immediately.

PART 3 EXECUTION

3.01 MANHOLE INSTALLATION

A. Excavate and backfill as specified in Section 02318 - Trenching and as indicated on the Drawings.

B. Maintain identification markings on installed pieces throughout installation.

C. Do not use sections with chips or cracks in the joint.

D. Engineer may inspect manhole sections, prior to installation.

E. Repair of manhole sections damaged during installation in accordance with manufacturer’s repair procedures; with the concurrence of the Engineer.

F. Bedding and backfill for tee-base pipe fitting: In accordance with Section 02318 - Trenching.
   1. Tee-base outlet: Vertical.
   2. Upper end of the vertical pipe stub creates a horizontal plane.
G. Tee bases:
   2. Vibrate to densify concrete and screed so first precast manhole riser section has a level, uniform bearing for full circumference.
   3. Use steel impression ring to create a groove into which the first manhole riser section tongue can be inserted.
   4. Install preformed plastic sealing gasket between groove and tongue and first manhole riser section.

H. Install joint sealant material in accordance with manufacturer’s instructions:

I. Fill threaded lifting inserts with grout.

J. Lay grade rings on joint sealant with sides plumb and tops level.

K. Set frame and covers as specified and as indicated on the Drawings.

L. Apply damproofing as indicated on the Drawings.
   1. Apply material in accordance with manufacturer recommendations over the entire exterior surface of the completed manhole, including base section, riser sections, cone section, and grade rings prior to backfilling the manhole.
   2. Allow waterproofing material to dry sufficiently before backfilling.

3.02 CLEANING

A. After completing each manhole, remove debris, construction materials, and equipment from the site of the work, grade, and smooth over the surface and leave the entire right-of-way in a clean, neat, and serviceable condition.

B. After completing each manhole, remove construction material debris from inside the manhole.

3.03 FUNCTIONAL TESTING

A. Provide materials for grouting and patching recommended by the manufacturer or an approved equal.

B. Vacuum testing in accordance with ASTM C1244.
   1. Install the vacuum test head on top of the manhole.
      a. Install and brace sealing devices on influent and effluent pipes.
   2. Draw a vacuum of 10 inches of mercury with a vacuum pump, deactivate the pump, and measure the actual elapsed time for the vacuum to drop to 9 inches of mercury.
3. Compare test results with the minimum time requirements stated in the table below.

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a. If the actual elapsed time is less than the time in the table, the manhole is defective, and it shall be repaired and retested until it is acceptable.

END OF SECTION
SECTION 02605
HIGH DENSITY POLYETHYLENE (HDPE) MANHOLES

PART 1    GENERAL

1.01    SUMMARY

A. Section includes: High density polyethylene (HDPE) manholes.

1.02    REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO).

B. ASTM International (ASTM):

C. International Organization of Standardization (ISO):
   1. 9001 - Quality Management Standard.
1.03 ABBREVIATIONS

A. HDPE: High-density polyethylene pipe.
B. PE: Polyethylene pipe.
C. ID: Inside diameter of piping or tubing.
D. OD: Outside diameter.
E. SDR: Standard dimension ratio.
F. RSC: Ring Stiffness Constant.

1.04 SUBMITTALS

A. Product data: Describe materials and installation equipment including fusion machine. Include optimum range of fusion conditions such as fusion temperature, interface pressure, and cooling time.
B. Manufacturer's Published Installation Instructions.
C. Proposed fittings for manhole connections.
D. Manhole design calculation and drawings.
E. Certificates:
   1. Submit manufacturer's certificate attesting that high-density polyethylene pipe (HDPE) and fitting types meet specified requirements.
   2. Manufacturer’s certification of date of manufacture of high-density polyethylene pipe and fittings for each lot delivered.
   3. ISO 9001 certificate by a third party confirming that ASTM test reports are valid and up to date at the time of the bid and during construction period.
F. Qualifications of installation crew for high-density polyethylene pipe including qualifications of the fusion machine technician.
   1. Furnish proof of training in the use of fusion equipment.

1.05 PRODUCT REQUIREMENTS

A. As specified in Section 01600 - Product Requirements.
B. Provide suitable quantities of lifting equipment to handle the manholes/risers and castings.
   1. In no case shall any equipment be used that is not rated to handle the intended loading or conditions of use to which it will be subjected, or which will damage or gouge the manhole components.
2. Dragging or dropping the manhole components shall not be allowed.

C. Source testing:
   1. Perform pre-production and post-production tests by manufacturer staff with a minimum of 5 years of experience in quality control, inspection, and testing of manholes.
   2. In lieu of this experience, witness of tests by up to 3 full-time District representatives.
   3. Inspect incoming polyethylene materials for density, melt flow rate, and contamination.
   4. Supplier provide certified cell classification properties of the material.
      a. Verified by manufacturer's quality control.
   5. Quality Control approval of incoming materials prior to processing into finished goods.
   6. Check outgoing materials for:
      a. Outside diameter, wall thickness, and eccentricity in accordance with ASTM D2122 at a frequency of at least once per hour.
      b. Out of roundness at a frequency of at least once per hour.
      c. Visually inspect straightness, inside and outside surface finish, markings, and end cuts in accordance with ASTM F714 on every length of pipe.
   7. Quality Control production checks and test for:
      a. Density in accordance with ASTM D1505 at a frequency of at least once per extrusion lot.
      b. Melt Index in accordance with ASTM D1238 at a frequency of at least once per day per extrusion lot.
      c. Carbon content in accordance with ASTM D1603 at a frequency of at least once per day per extrusion line.
      d. Quick burst pressure in accordance with ASTM D1599 at a frequency of at least once per day per line.
      e. Ring tensile strength in accordance with ASTM D2290 at a frequency of at least once per day per line.
   8. Use X-ray inspection to inspect molded fittings for voids.
   9. Test knit line strength.
   10. Inspect fabricated fittings for joint quality and alignment.
   11. Permanent records: Maintain permanent QC and QA records.

1.06 DESIGN CRITERIA

A. Manholes shall not include steps.

B. Manhole lids: Locking type.

C. Manhole bases:
   1. Constructed as part of the pipe installation or using tee risers.
D. Manhole riser:
   1. Made of the same pipe material selected for the project, providing a sealed connection between the pipe base and riser as indicated on the Drawings.
   2. Manufactured specifically for this project and no materials shall be furnished from stock unless approved by the Engineer.

E. Manhole provider shall coordinate with the pipe manufacturer for dimensions and connections.

F. Manhole systems:
   1. Provided by a single manufacturer.

G. Frames and covers:
   1. Provided by a single manufacturer unless otherwise approved by the Engineer.

1.07 QUALITY ASSURANCE

A. Fusion machine technician qualifications:
   1. 3 years of experience in the installation of similar PE piping systems from the same manufacturer.
   2. Contractor shall certify, in writing, that persons making heat fusion joints have received training in the manufacturer's recommended procedure and have had at least 3 years current experience in the heat fusion butt welding process.
   3. Contractor shall maintain records of trained personnel, and shall certify that training was received not more than 12 months before commencing construction.

B. Smooth interior profile wall high-density polyethylene (HDPE) pipe and fittings including polyethylene pipe specified in other Sections shall be from a single manufacturer.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Protect manhole materials from sunlight, scoring, and distortion.

B. Do not allow surface temperatures on manhole and fittings to exceed 160 degrees Fahrenheit.

C. Store and handle manhole and fittings as recommended by manufacturer in published instructions.

D. Package products for shipment in a manner suitable for safe transport by commercial carrier.
   1. Perform receiving inspection and report any shipping damage to the manufacturer within 7 days.
2. Prior to making a terminal connection with manhole, the temperature of the manhole should be allowed to approach the service temperature at which the manhole is intended to operate.

1.09 WARRANTY

A. As specified in General Conditions.

PART 2 PRODUCTS

2.01 MATERIALS

A. Extruding and molding material: Virgin material containing no scrap, regrind, or rework material except where permitted in the referenced standards.

B. Fittings:
   1. Same material as the pipe and of equal or greater pressure rating.
   2. For piping connections to manhole structure, utilize coupling appropriate for pipe material, test pressure requirements.

C. Base materials:
   1. Riser shaft, top, base and stubout pipes: DR 17 HDPE pipe meeting the requirements of cell classification 335444C or higher in accordance with ASTM D3350.

D. Fabricate manhole in accordance with ASTM F1759 based on project soil information and as indicated on the Drawings.

E. Riser shaft:
   1. Manufactured in accordance with ASTM F894.
   2. Solid wall construction only.
   3. Standard Inside-Diameter Dimension Ratio (SIDR) or the Inside-Dimension Ratio (IDR):
      a. Sufficient wall thickness that the manhole meets the requirements as specified in this Section or as indicated on the Drawings.
   4. Manufacture manhole riser with required spool pieces for connection to piping indicated on the Drawings.
      a. Join in accordance with the manufacturer's recommendations.

F. Gaskets: Neoprene gaskets with the physical requirements specified in the non-pressure requirements in accordance with ASTM F477.
   1. SDR or ring stiffness constant classification.
   2. Production code designating plant location, machine, and date of manufacture.
2.02 BASIS OF DESIGN

A. Design in accordance with local jurisdiction requirements, including but not limited to the following:
   1. Manhole frames and covers.
   2. Manhole diameter tolerance.
   3. Manhole length.
   4. Manhole cover bolting.
   5. Manhole backfill.

B. Structural design calculations:
   1. Load rating of manhole:
      a. Design to support an AASHTO Standard Specifications for Highway Bridges, H-20 vehicle loading.
   2. Resist buoyancy:
      a. Design with sufficient bottom anchorage and side friction to resist buoyancy.
      b. Depths will be as indicated on the Drawings.
      c. Refer to the geotechnical report for soil condition including fully saturated soil conditions.
      d. Anti-flotation flange:
         1) Exterior of manhole riser shall incorporate a 3-inch wide flange at its base.
         2) Upon joining of manhole riser to pipe tee, place sufficient concrete around tee and manhole riser to prevent buoyancy.
         3) Encase anti-flotation flange in a minimum of 6 inches of concrete.

C. Manholes, grade rings, risers, and bases:
   1. Manhole:
      a. Nominal sizes as indicated on the Drawings.
      b. Opening: Not less than 30 inches.
   2. Grade rings:
      a. At least 1 but not more than 2 grade rings shall be used.
      b. Maximum total distance from top of cone section to final grade: 18 inches.
   3. Cone and riser sections:
      a. As specified in this Section and as indicated on the Drawings.
      b. Cone sections shall be concentric.
   4. Manhole bases:
      a. As specified in this Section and as indicated on the Drawings.
      b. Provide corrosion protection system on unlined concrete.
2.03 IDENTIFICATION MARKINGS

A. Identification marks on the exterior of bases, risers, grade rings, and include the following information:
   1. Date of manufacture of the item.
   2. Name or trademark of the manufacturer.
   3. Internal diameter in inches.
   4. Number of the manhole as indicated on the Drawings.
   5. Pipe size.

2.04 QUALITY CONTROL

A. Manufacturer to provide permanent quality control department and laboratory facility capable of performing inspections and testing as specified by this Section.

B. Material testing, inspection procedures, and manufacturing process are subject to inspection by the District or District's representative.

C. Perform manufacturer's tests and inspections in accordance with the referenced standards and as specified in this Section including the following:
   1. Provide the Manufacturer's Certificate of Source Testing as specified in Section 01600 - Product Requirements.
   2. Provide services of representative throughout the project duration when deemed necessary by the Engineer.
   3. Calibrate within last 12 months for equipment such as scales, measuring devices and calibration tools used in the manufacturing of manhole.
      a. Each device used in the manufacture of manholes is required to have a tag recording date of last calibration.
      b. Devices are subject to inspection by Engineer.

D. Furnish labor necessary to assist the Engineer in inspecting manholes upon delivery.

E. Remove rejected manholes immediately.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. Where not otherwise specified, install manholes in accordance with ASTM F645, or manufacturer's published instructions for installation of manholes, as applicable to the particular type of manhole.
   2. Provide molded transition fittings for transitions from PE to metal or IPS pipe.
      a. Do not thread or solvent weld PE pipe.
B. Installation of manholes:
   1. Achieve stable and permanent support under and around the manhole.
      a. Install the manhole in a dry trench.
      b. Place 8 inches minimum of crushed stone or aggregate base course to provide a stable foundation.
      c. Compact the foundation material to 95 percent Standard Proctor density.
      d. Alternatively, the manhole can be set on a properly designed reinforced concrete slab on a stable foundation.
   2. Backfilling:
      a. Extend embedment surrounding the manhole to at least 3.5 feet or to the trench wall, whichever is the greater distance, for manholes placed in unstable in-situ soils.
      b. In unstable soil, extend embedment to a distance equal to at least 1 manhole diameter (but not less than 3.5 feet) or to the trench wall, whichever is the greater distance.
      c. Place embedment from the invert to the top of the manhole.
      d. Embedment material: aggregate base course compacted to at least 90 percent Standard Proctor density in 12-inch lifts.
      e. Place backfill evenly around the manhole to prevent moving the manhole out of alignment.
   3. Install manholes in accordance with the manufacturer's written instructions.
   4. Provide connections as required.

3.02 CLEANING

A. After completing each manhole, remove debris, construction materials, and equipment from the site of the work, grade, and smooth over the surface and leave the entire right-of-way in a clean, neat, and serviceable condition.

B. After completing each manhole, remove construction material debris from inside the manhole.

3.01 FUNCTIONAL TESTING

A. Provide materials for patching recommended by the manufacturer or an approved equal.

B. Vacuum testing in accordance with ASTM C1244.
   1. Install the vacuum test head on top of the manhole.
      a. Install and brace sealing devices on influent and effluent pipes.
   2. Draw a vacuum of 10 inches of mercury with a vacuum pump, deactivate the pump, and measure the actual elapsed time for the vacuum to drop to 9 inches of mercury.
3. Compare test results with the minimum time requirements stated in the table below.

<table>
<thead>
<tr>
<th>Minimum Elapsed Time, Minutes: Seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manhole Depth, ft.</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>8</td>
</tr>
<tr>
<td>10</td>
</tr>
<tr>
<td>12</td>
</tr>
<tr>
<td>14</td>
</tr>
<tr>
<td>16</td>
</tr>
<tr>
<td>18</td>
</tr>
<tr>
<td>20</td>
</tr>
<tr>
<td>22</td>
</tr>
<tr>
<td>24</td>
</tr>
<tr>
<td>26</td>
</tr>
<tr>
<td>28</td>
</tr>
<tr>
<td>30</td>
</tr>
</tbody>
</table>

a. If the actual elapsed time is less than the time in the table, the manhole is defective, and it shall be repaired and retested until it is acceptable.

END OF SECTION
SECTION 02620
FILTER FABRIC

PART 1   GENERAL

1.01 SUMMARY

A. Section includes: Nonwoven filter fabric.

1.02 REFERENCES

A. ASTM International (ASTM):

1.03 DEFINITIONS


1.04 SUBMITTALS

A. Product data.

B. Samples.

C. Quality control submittals:
   1. Certificates of Compliance.
   2. Manufacturer's Instructions.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Storage and protection:
   1. Furnish filter fabric in protective covers capable of protecting the fabric from ultraviolet rays, abrasion, and water.
1.06 PROJECT CONDITIONS

A. Take field measurements to determine the lengths and dimensions of the surfaces to receive the fabric.

PART 2 PRODUCTS

2.01 FILTER FABRIC

A. Manufacturers:
   1. One of the following or equal:
      a. Propex, Geotex 401.
      b. Ten Cate Geosynthetics, Mirafi 140N.

B. Material Requirements:
   1. Physical properties: Meet the following minimum requirements:

<table>
<thead>
<tr>
<th>Property(1)</th>
<th>Test Method</th>
<th>Unit</th>
<th>Requirements(1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Weight</td>
<td>ASTM D5261</td>
<td>oz</td>
<td>4.0</td>
</tr>
<tr>
<td>Grab Tensile Strength</td>
<td>ASTM D4632</td>
<td>lbs</td>
<td>100</td>
</tr>
<tr>
<td>Grab Elongation</td>
<td>ASTM D4632</td>
<td>%</td>
<td>50</td>
</tr>
<tr>
<td>Trapezoid Tear Strength</td>
<td>ASTM D4533</td>
<td>lbs</td>
<td>50</td>
</tr>
<tr>
<td>CBR Puncture Resistance</td>
<td>ASTM D6241</td>
<td>lbs</td>
<td>300</td>
</tr>
<tr>
<td>UV Resistance (strength retained at 500 hrs)</td>
<td>ASTM D4355</td>
<td>%</td>
<td>70</td>
</tr>
<tr>
<td>Apparent Opening Size (AOS)</td>
<td>ASTM D4751</td>
<td>US sieve</td>
<td>70</td>
</tr>
<tr>
<td>Permittivity</td>
<td>ASTM D4491</td>
<td>sec$^1$</td>
<td>1.7</td>
</tr>
<tr>
<td>Flow Rate</td>
<td>ASTM D4491</td>
<td>gpm/ft$^2$</td>
<td>130</td>
</tr>
</tbody>
</table>

Notes:
(1) Minimum average roll values.

2.02 GEOTEXTILE FABRIC FOR RIP RAP

A. Manufacturers: One of the following or equal:
   1. Propex Operating Company, Geotex 1071 or 1201.
   2. Contech Construction Products, Inc.; C-80NW.
   3. Nicolon Corporation, Mirafi 180NC or 1100NC.
PART 3  EXECUTION

3.01  EXAMINATION

A. Verification of conditions: Verify that conditions are satisfactory for the installation of filter fabric.

3.02  PREPARATION

A. Surface preparation:
   1. During grading operations, take care not to disturb the subgrade.
   2. This may require use of lightweight dozers for low strength soils such as saturated, cohesionless, or low cohesion soils.

B. Prior to placement of fabric: Prepare surface to smooth condition free of debris, depressions, or obstructions that may damage the fabric.

C. Geotextile fabric:
   1. At the time of installation, the geotextile fabric shall be rejected if it has defects, rips, holes, flaws, deterioration, or damage incurred during manufacture, transportation, or storage.
   2. The surface that is to receive the geotextile fabric shall be prepared to a relatively smooth condition, free of obstructions, depressions, debris, and soft or low-density pockets of material.
   3. Erosion features such as rills and gullies shall be graded out of the surface before geotextile fabric placement.

3.03  INSTALLATION

A. Follow manufacturer's installation instructions and as complimented in this Section.

B. Place the filter fabric smoothly without folds or wrinkles.

C. Use special care when placing the filter in contact with the soil so that no void spaces occur between the filter and the prepared surface.

D. Overlap the parallel rolls and ends of rolls a minimum of 24 inches and not less than manufacturer's instructions.

E. Do not drag filter fabric across subgrade.

F. Make overlaps at ends of rolls in the direction of the aggregate placement with the previous roll on top.

G. Use lightweight dozers if necessary. Do not allow equipment directly on filter fabric.

H. Temporary pinning of the textile fabric to help hold it in place until the stone protection and embankment fill is placed will be allowed.
I. Remove temporary pins as the stone protection and embankment fill is placed to relieve high tensile stress, which may occur during placement of material on the geotextile fabric.

J. Protect geotextile at all times during construction from contamination by surface runoff.
   1. Replace any geotextile fabric so contaminated with uncontaminated geotextile fabric.
   2. Replace any geotextile fabric that is damaged during its installation.
   3. In no case shall any type of equipment be allowed on the unprotected geotextile fabric.

3.04 FIELD QUALITY CONTROL

   A. Inspection:
      1. Before covering, the condition of the fabric will be observed by the Engineer to determine that no holes or rips exist in the fabric.
      2. Repair all holes and rips by placing a new layer of fabric extending beyond the defect in all directions a distance equal to the minimum overlap required for adjacent rolls.

END OF SECTION
PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Asphalt pavement on prepared subgrade or aggregate base course to lines, grades, and compacted thickness as indicated on the Drawings.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft. lbf/ft^3)(2,700 kN-m/m^3).

B. Caltrans Standard Test Methods:
   2. Calif Test 304 - Preparation of Bituminous Mixtures for Testing.
   4. Calif Test 375 - Determining the In-Place Density and Relative Compaction of AC Pavement.

   1. Section 37 - Bituminous Seals.
   2. Section 39 - Hot Mix Asphalt.
   3. Section 88 - Geosynthetics.
   4. Section 92 - Asphalts.
   5. Section 93 - Liquid Asphalts.

1.03 SYSTEM DESCRIPTION

A. This Work shall consist of furnishing and mixing aggregate and asphalt binder at a central mixing plant, spreading and compaction of the mixture as specified and as indicated on the Drawings.
B. In general, asphalt concrete and asphalt concrete base shall conform to Section 39 “Hot Mix Asphalt,” and all applicable referenced sections of the Caltrans Standard Specifications:
   1. Where conflicts exist, this specification shall govern.

1.04 DEFINITIONS

A. “Asphalt Concrete” as used by Caltrans shall be considered the “Surface Course,” or the final lift of the pavement section.

B. “Asphalt Concrete Base” as used by Caltrans shall be the remaining portion of the asphalt pavement section excluding the final lift.

C. “Asphalt Pavement” shall be the total pavement section of asphalt including Asphalt Concrete and Asphalt Concrete Base.

1.05 SUBMITTALS

A. Mix design.

B. Shop drawings.

C. Product data:
   1. Asphalt.
   2. Asphalt aggregate.

D. Quality control submittals:
   1. Test results.
   2. Certificate of Compliance.

E. Equipment list.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Asphalt pavement delivery:
   1. Transport the mixture from the mixing plant to the point of use in vehicles having tight bodies previously cleaned of all foreign materials.
   2. Treat bodies as necessary to prevent material from sticking to the bodies.
   3. Cover each load with canvas or other suitable material of sufficient size and thickness to protect the asphalt mixture from the weather.
1.07 PROJECT CONDITIONS

A. Environmental requirements:
   1. Asphalt concrete:
      a. Place asphalt concrete only when surface is dry, and when atmospheric
         temperature in the shade is 40 degrees Fahrenheit and rising, or above
         50 degrees Fahrenheit if falling.
      b. Do not place asphalt concrete when weather is foggy or rainy, when base
         on which material is to be placed is in wet or frozen conditions, or when,
         in the opinion of the Engineer, weather conditions will prevent proper
         handling, finishing, or compaction of the mixtures.

PART 2 PRODUCTS

2.01 ASPHALT PAVEMENT MATERIALS

A. Asphalts:
   1. Asphalt binder: Steam-refined paving asphalt, PG 64-10, conforming to
      Section 92-1.02C “Grades” of the Caltrans Standard Specifications.
   2. Tack coat: Grade SC-70, conforming to Section 93 of the Caltrans Standard
      Specifications.
   3. Fog seal: Asphaltic emulsion, Grade SS-1h, conforming to Section 94 of the

B. Asphalt aggregate:
   1. Aggregate for asphalt concrete shall conform to Section 39-1.02E of the
      Caltrans Standard Specifications for Type B grading, 1/2-inch maximum,
      medium.
   2. Aggregate for asphalt concrete base shall conform to Section 39-1.02E of the
      Caltrans Standard Specifications for Type B grading.
   3. The use of reclaimed asphalt pavement (RAP) in asphalt concrete and asphalt
      concrete base is prohibited.

C. Asphalt pavement shall be produced in a batch mixing plant, a continuous pugmill
   mixing plant, or dryer-drum mixing plant:
   1. Proportioning shall conform to Section 39-3.03 of the Caltrans Standard
      Specifications.
   2. Mixing shall conform to Section 39-3.04 of the Caltrans Standard
      Specifications.

2.02 FOG SEAL

A. A fog seal shall be applied to all surfaces of Types A and B asphalt concrete in
   conformance with the provisions in Section 37-1, and all applicable referenced
   sections of the Caltrans Standard Specifications.
2.03 AGGREGATE BASE COURSE

A. Aggregate base course: As specified in Section 02050 - Soils and Aggregates for Earthwork.

B. Aggregate base course shall be placed at the following locations:
   1. All asphalt pavement.

C. Compacted thickness of aggregate base course shall be as indicated on the Drawings.

2.04 EQUIPMENT

A. Spreading and compacting equipment:
   1. Spreading equipment shall conform to Section 39-1.10 and all applicable referenced sections of the Caltrans Standard Specifications:
      a. Only in areas inaccessible to the machine, by approval of the Engineer, will hand spreading be permitted.
   2. Compaction equipment shall conform to Section 39-1.10 and all applicable referenced sections of the Caltrans Standard Specifications.

2.05 SOURCE QUALITY CONTROL

A. The Engineer will perform sampling and tests of materials in accordance with California Test Method Number 304 and California Test Method Number 362 or 379, as applicable. Samples will be taken from materials as delivered to the site.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of conditions: Verify surfaces and site conditions are ready to receive work. If unsatisfactory conditions exist, do not commence installation until such conditions have been corrected. Beginning application means acceptance of existing conditions.

3.02 PREPARATION

A. Protection:
   1. Protect concrete pavements and walks, curbs and bases, and other improvements adjacent to the operations with suitable materials.
   2. Building and other surfaces shall be covered with paper or other protection, when required.
   3. Contractor shall be responsible for any damage caused by Contractor’s employees. All damage caused by the Contractor’s operations shall be repaired to the satisfaction of the Engineer at no additional cost to District.
B. Subgrade preparation:
   1. Immediately prior to applying tack coat, or immediately prior to placing the asphalt pavement when tack coat is not required, the subgrade to receive asphalt pavement shall conform to the compaction requirement and elevation tolerances specified for the material involved and shall be cleaned to remove any loose or extraneous material.
   2. If the asphalt pavement is to be placed on an existing base or pavement that was not constructed as part of the contract, the Contractor shall clean the surface by sweeping, flushing, or other means to remove all loose particles of paving, all dirt, and all other extraneous material immediately before applying the tack coat.

3.03 TACK COAT

A. Tack coat:
   1. A tack coat of asphaltic emulsion shall be applied to all vertical surfaces of existing pavement, curbs, gutters, and construction joints in the surfacing against which additional material is to be placed, or as otherwise specified in this Section.
   2. Tack coat shall be applied in one application at a rate of 0.1 gallons per square yard of surface covered.

3.04 ASPHALT PAVEMENT

A. Placing materials in a windrow, then picking it up and placing it in the asphalt paver with loading equipment, will be permitted provided that:
   1. The asphalt paver is of such design that the material will fall into a hopper that has a movable bottom conveyor to feed and screed.
   2. The loader is constructed and operated so that substantially all of the material deposited into windrows is picked up and deposited into the paving machine.
   3. The windrow is deposited only so far in advance of the paver to provide for continuous operation of the paver and not so far as to allow the temperature of the asphalt pavement in the windrow to fall below 260 degrees Fahrenheit.

B. Unless lower temperatures are directed by the Engineer, asphalt concrete shall be spread, and the first coverage of initial or breakdown compaction shall be performed when the temperature of the mixture is not less than 250 degrees Fahrenheit, and all breakdown compaction shall be completed before the temperature of the mixture drops below 205 degrees Fahrenheit.

C. Asphalt pavement shall be spread and compacted in the number of layers and of the thicknesses indicated in the following table:
   1. A thickness tolerance of within 0.1 inches is allowed for asphalt concrete.
   2. A total thickness tolerance of within 0.2 inches is allowed for asphalt concrete base.
<table>
<thead>
<tr>
<th>Total Thickness Indicated on Drawings&lt;sup&gt;(1)&lt;/sup&gt;</th>
<th>Number of Lifts</th>
<th>Top Layer Thickness (inches)</th>
<th>Next Lower Layer Thickness (inches)</th>
<th>All Other Lower Layer Thicknesses (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-1/4 - 4-3/4 inches</td>
<td>2</td>
<td>1-3/4</td>
<td>2-1/2&quot;</td>
<td>1-3/4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Min. Max.</td>
</tr>
</tbody>
</table>

**Notes:**

(1) When pavement-reinforcing fabric is shown to be placed between layers of asphalt pavement, the thickness of asphalt pavement above the pavement-reinforcing fabric shall be considered to be the “Total Thickness Indicated on the Drawings” for the purpose of spreading and compacting the asphalt pavement above the pavement-reinforcing fabric.

(2) At least 2 layers shall be placed if the total thickness is less than 5 inches. At least 3 layers shall be placed if the total thickness is more than 5 inches, and less than 10-1/2 inches. At least 4 layers shall be placed if the total thickness is greater than 10-1/2 inches.

D. A layer shall not be placed over another layer which exceeds 3 inches in compacted thickness until the temperature of the layer which exceeds 3 inches in compacted thickness is less than 160 degrees Fahrenheit at mid depth:
   1. If the temperature of any layer drops below 140 degrees Fahrenheit, or if directed by the Engineer, apply tack coat before placing next layer.

E. Unless otherwise indicated on the Drawings, asphalt mixtures shall not be handled, spread, or windrowed in a manner that will stain the finished surface of any pavement or other improvements.

F. The completed mixture shall be deposited on the prepared subgrade at a uniform quantity per linear foot, as necessary to provide the required compacted thickness without resorting to spotting, picking up, or otherwise shifting the mixture.

G. Spreading:
   1. All layers of asphalt pavement shall be spread with an asphalt paver and shall conform to Section 39-1.11 and all applicable referenced sections of the Caltrans Standard Specifications.
   2. At locations where the asphalt pavement is to be placed over areas inaccessible to spreading and rolling equipment, all layers of asphalt pavement shall be distributed directly out of the back of the dump truck and spread by hand:
      a. Asphalt pavement spread by hand shall be compacted thoroughly to the required lines, grades, and cross-sections by means of pneumatic tampers, or by other methods that will produce the same degree of compaction as pneumatic tampers.
H. Compaction:
   1. Compaction of asphalt pavement shall conform to Sections 39-1.11, 39-3.03,
      39-3.04, and all applicable referenced sections of the Caltrans Standard
      Specifications.
   2. Minimum required density for each layer of asphalt pavement shall be
      95 percent of that obtained in the laboratory in accordance with ASTM Test
      Method D1561.

I. Segregation shall be avoided, and the surfacing shall be free of pockets of coarse or
   fine material. Asphalt pavement containing hardened lumps shall not be used:
   1. In areas inaccessible to paving and compacting equipment where spreading is
      done by hand, minimize the amount of segregation.

J. Location of longitudinal joints in the top layer will be determined by the Engineer
   and shall not adversely affect the quality of the finished product.

K. At all locations, or as directed by the Engineer, the asphalt concrete shall be square
   and at least 1-inch thick when conforming to existing surfacing. Tapering or
   feathering is not allowed.

3.05 EXISTING AC PAVEMENT MILL AND OVERLAY

A. Contractor shall cold mill top lift of existing paving. Contractor shall be responsible
   for removal and disposal of all milled asphalt debris.

B. Contractor shall provide AC overlay with horizontal tack coat.

C. The Contractor shall take particular care to only remove material to the limits
   specified and without damage to the areas that are to remain. Damage to areas
   that are to remain in place shall be repaired to a condition satisfactory to the
   District. Any additional material removed and replaced outside the specified limits
   (as a result of damage or Contractors of means and methods) shall be at the
   Contractor’s expense.

D. All work will be done under the supervision of the OWNER’S representative.

E. Special care shall be taken to avoid spilling bituminous material on adjacent
   concrete surfaces. Any spills of bituminous material shall be cleaned up
   immediately. Spills of fuels, oils, chemicals or other materials which could pose a
   threat to ground water shall be cleaned up immediately by the Contractor. If the
   spill is a reportable amount, the Contractor should contact the local authority for
   clean-up of the spill. Use of chemicals, refueling activities, and maintenance
   activities shall be carefully controlled to minimize the potential for spills.

F. All removed material shall be spoiled entirely at Contractor’s expense off the
   project site to an approved disposal area through the County or City. In no instance
   shall excess spoil become a public nuisance or threat to public safety.
G. The Contractor shall be responsible for protecting utilities from damage and all vehicles/property from damage from drifting sealcoat material. The Contractor is responsible for any vehicle/property cleaning and repainting.

H. Any damage, ruts or erosion caused by the CONTRACTOR’s operations must be repaired to the satisfaction of the OWNER’S representative.

I. Contractor shall perform his operations so that existing roads and other paved surfaces adjacent to or in the vicinity of the work site are not damaged. Contractor shall repair any damaged pavement which results from his operations (except that which is specifically a part of the Contract Work) to the satisfaction of the District, all at his expense.

J. Contractor shall be responsible for the proper disposal of all waste materials resulting from his operations, including rubbish, packaging materials, discarded equipment parts, and damaged construction materials, in a manner and at locations suitable to the District and in compliance with all health and other regulatory agencies.

K. All work sites shall be restored to pre-job conditions and shall meet the requirements of the District and property owners.

3.06 FIELD QUALITY CONTROL

A. Contractor shall control the quality of Work and shall provide adequate testing to ensure compliance with these Specifications:
   1. The type and size of the samples shall be suitable to determine conformance with stability, density, thickness, and other specified requirements. Use an approved power saw or core drill for cutting samples. Furnish all tools, labor, and materials for cutting samples, testing, and replacing the pavement where samples were removed. Take a minimum of 1 sample for every 4,000 square feet of asphalt pavement placed.

B. All asphalt pavement shall match the grades indicated on the Drawings and shall be completely free from unintended hollows and high spots:
   1. After completion of paving work, all paving shall be flooded with water. Any ponding that results in standing water greater than 3/4 inch in depth shall be ringed with chalk. Such hollows shall be corrected by removing and replacing the asphalt concrete. The asphalt concrete patch shall be square and at least 1-inch thick when conforming to existing surfacing. Tapering or feathering is not allowed.

C. Contractor shall perform in-place density and compaction tests of the completed pavement in accordance with California Test Method Number 375, to determine compliance with the specified requirements. Submit test results to Engineer for approval.
D. Cracks, settling of surface, improper drainage, improper compaction, and sloppy connection to previously laid surfaces will be construed as improper workmanship and will not be accepted.

3.07 MAINTENANCE OF PAVEMENT

A. Upon completion of final rolling, traffic shall not be permitted on the finished pavement for at least 6 hours, or until the asphalt pavement has cooled sufficiently to withstand traffic without being deformed.

3.08 WORKMANSHIP AND WARRANTY

A. Contractor shall provide written warranty against defects in materials or workmanship for a period of not less than 1 year upon completion of Work.

END OF SECTION
SECTION 02772
CONCRETE CURBS, GUTTERS, AND SIDEWALKS

PART 1   GENERAL

1.01 SUMMARY

A. Section includes: Concrete curbs, gutters, sidewalks, driveways, access ramps, and alley intersections.

1.02 SYSTEM DESCRIPTION

A. Performance requirements: Construct various types of concrete curb, gutter, sidewalk, driveways and alley intersections to dimensions and details indicated on the Drawings.

1.03 SUBMITTALS

A. Product data: Submit data completely describing products.

B. Samples: Submit samples when requested.

PART 2   PRODUCTS

2.01 MATERIALS

A. Concrete: Class A, as specified in Section E03300 - Cast-in-Place Concrete.

B. Curb finishing mortar: 1 part portland cement to 2 parts sand.

C. Form release material: Light oil or other releasing agent of type which does not discolor concrete or interfere with the application of finishing mortar to curb tops and faces.

D. Joint materials:
   1. Expansion: As specified in Section 03150 - Concrete Accessories.

PART 3   EXECUTION

3.01 EXAMINATION

A. Verification of Conditions:
   1. Verify field conditions, including subgrade condition and interferences, before beginning construction.
3.02 PREPARATION

A. Surface preparation:
   1. Subgrade:
      a. Construct and compact true to grades and lines indicated on the Drawings and requirements as specified Section 02050 - Soils and Aggregates for Earthwork.
      b. Remove soft or unsuitable material to depth of not less than 6 inches below subgrade elevation and replace with satisfactory material.
   2. Forms and subgrade: Water immediately in advance of placing concrete.

3.03 INSTALLATION.

A. Forms:
   1. Carefully set to line and grade and securely stake in position forms conforming to dimensions of items to be constructed.
   2. Thoroughly clean prior to each use and coat with form releasing material.

B. Expansion and weakened-plane joints:
   1. Expansion joints:
      a. Construct vertically, and at right angles to centerline of street and match joints in adjacent pavement or sidewalks.
      b. Constructed at radius points, driveways, alley entrances, and at adjoining structures.
      c. Fill joints with expansion joint filler material.
   2. Weakened-plane joints:
      a. Construct as indicated on the Drawings.
      b. Match joint locations and details in adjacent curbs, gutters, and sidewalks.

C. Concrete:
   1. Placing:
      a. Thoroughly spade concrete away from forms so that no rock pockets exist next to forms and so that no coarse aggregate will show when forms are removed.
   2. Compacting:
      a. Compact by mechanical vibrators accepted by the Engineer.
      b. Continue tamping or vibrating until mortar flushes to surface and coarse aggregate is below concrete surface.
   3. Form removal:
      a. Front form faces: Do not remove before concrete has taken initial set and has sufficient strength to carry its own weight.
      b. Gutter and rear forms: Do not remove until concrete has hardened sufficiently to prevent damage to edges. Take special care to prevent damage.
4. Finishing and curing: Comply with requirements as specified in Section 03366 - Tooled Concrete Finishing except as modified here:
   a. As soon as curb face forms are stripped, apply finishing mortar to the top and face of curb and trowel to a smooth, even finish. Finish with fine haired broom in direction of work.
   b. Where curb is installed without integral gutter, extend finish 2 inches below grade.
   c. Edge concrete at expansion joints to 1/4 inch radius.
   d. Flow lines of gutters shall be troweled smooth 4 inches out from curb face for integral curb and gutter and 4 inches on both sides of flowline for gutters without curbs.

D. Backfilling:
   1. Unless otherwise specified, backfill behind curbs, gutters, or sidewalks with soil native to area and to lines and grades indicated on the Drawings.

3.04 FIELD QUALITY CONTROL

A. Tests:
   1. Curbs and gutters:
      a. Test face, top, back, and flow line with 10 foot straightedge or curve template longitudinally along surface.
      b. Correct deviations in excess of 1/4 inch.
   2. Gutters:
      a. Frequency of testing: When required by the Engineer, where gutters have slope of 0.8 foot per 100 feet or less, or where unusual or special conditions cast doubt on capability of gutters to drain.
      b. Test method: Establish flow in length of gutter to be tested by supplying water from hydrant, tank truck, or other source.
      c. Required results:
         1) 1 hour after supply of water is shut off, inspect gutter for evidence of ponding or improper shape.
         2) In event water is found ponded in gutter to depth greater than 1/2 inch, or on adjacent asphalt pavement, correct defect or defects in manner acceptable to the Engineer without additional cost to the Contract.

3.05 ADJUSTING

A. Repair portions of concrete damaged while stripping forms or, when damage is severe, replace such work at no additional cost to the Contract. Evidence of repairs shall not be noticeable in the finished product.
B. Remove and replace sections of work deficient in depth or not conforming to requirements indicated on the Drawings and specified in the Specifications at no additional cost to the Contract. Removal and replacement shall be the complete section between 2 joints.

END OF SECTION
SECTION 03055
ADHESIVE-BONDED REINFORCING BARS AND ALL THREAD RODS IN CONCRETE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Bonding reinforcing bars and all thread rods in concrete using adhesives.

1.02 REFERENCES

A. American Concrete Institute (ACI).
   1. 355.4 - Qualification of Post-Installed Adhesive Anchors in Concrete and Commentary.

B. ASTM international (ASTM):

C. Concrete Reinforcing Steel Institute (CRSI).

D. ICC Evaluation Service, Inc. (ICC-ES):
   1. AC308 - Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements.

E. Society for Protective Coatings (SSPC):
   1. SP-1 - Solvent Cleaning.

1.03 DEFINITIONS

A. Evaluation Service Report (ESR): Report prepared by ICC-ES, or other testing agency acceptable to Engineer and to the Building Official, that documents testing and review of a product to confirm that it complies with the requirements of designated ICC-ES Acceptance Criteria, and to document its acceptance for use under the Building Code specified in Section 01410 - Regulatory Requirements.

1.04 SUBMITTALS

A. Product data: Technical data for adhesives, including:
   1. Manufacturer's printed installation instructions (MPII).
2. Independent laboratory test results indicating allowable loads in tension and shear for concrete of the types included in this Work, with load modification factors for temperature, spacing, edge distance, and other installation variables.
3. Handling and storage instructions.

B. Quality control submittals:
1. Special inspection: Detailed step-by-step instructions for the special inspection procedures required by the building code specified in Section 01410 - Regulatory Requirements.
2. For each adhesive to be used, Evaluation Report confirming that the product complies with the requirements of AC308 for both un-cracked and cracked concrete and for use in Seismic Design Categories A through F.
3. Installer qualifications:
   a. Submit evidence of successful completion of adhesive manufacturer's installation training program.
   b. Submit evidence of current certification for installation of inclined and overhead anchors under sustained tension loading.

C. Inspection and testing reports:
1. Inspections: Field quality control: Reports of inspections and tests.
   a. Inspections: Field quality assurance: Reports of special inspections and tests.

1.05 QUALITY ASSURANCE

A. Qualifications:
1. Installation requirements:
   a. Have available at the site, and install anchors in accordance with, the adhesive manufacturer's printed installation instructions.
2. Installer qualifications:
   a. Demonstrating successful completion of adhesive manufacturer's on-site training program for installation of adhesive-bonded anchors.
   b. Holding current certification for installation of adhesive-bonded anchors by a qualified organization acceptable to the Engineer and to the Building Official.
   1) Organizations/certification programs deemed to be qualified are:
      a) ACI-CRSI Adhesive Anchor Installer Certification Program.
      b) Adhesive anchor manufacturer's certification program, subject to acceptance by the Engineer and the Building Official.
1.06 DELIVERY, STORAGE, AND HANDLING

A. Store and protect products as follows, unless more restrictive requirements are recommended by the manufacturer:
   1. Store adhesives and adhesive components on pallets or shelving in a covered-storage area protected from weather.
   2. Control temperature to maintain storage within manufacturer's recommended temperature range.
      a. If products have been stored at temperatures outside manufacturer's recommended range, test by methods acceptable to the Engineer to confirm acceptability before installing in the Work.
   3. Dispose of products that have passed their expiration date.

1.07 PROJECT CONDITIONS

A. As specified in Section 01610 - Project Design Criteria.

B. Seismic Design Category (SDC) for structures is indicated on the Drawings.

PART 2 PRODUCTS

2.01 GENERAL

A. Like items of materials: Use end products of one manufacturer in order to achieve structural compatibility and singular responsibility.

B. Adhesives shall have a current Evaluation Report documenting testing and compliance with the requirements or ACI 355.4 and of ICC-ES AC308 for use with un-cracked concrete and with cracked concrete in the Seismic Design Category specified.

C. Bond reinforcing bars and all thread rods in concrete using epoxy adhesive unless other adhesives specified are specifically indicated on the Drawings or approved in writing by the Engineer.

2.02 EPOXY ADHESIVE

A. Materials:
   1. Meeting the physical requirements of ASTM C881, Type IV, Grade 3, Class B or C depending on site conditions.
   2. 2-component, 100 percent solids, insensitive to moisture.
   3. Cure temperature, pot life, and workability: Compatible with intended use and environmental conditions.
B. Packaging:
   1. Disposable, self-contained cartridge system furnished in side-by-side cartridges designed to fit into a manually or pneumatically operated caulking gun, and with resin and hardener components isolated until mixing through manufacturer's static mixing nozzle.
      a. Nozzle designed to dispense components in the proper ratio and to thoroughly blend the components for injection from the nozzle directly into prepared hole.
      b. Provide nozzle extensions as required to allow full-depth insertion and filing from the bottom of the hole.
   2. Container markings: Include manufacturer's name, product name, batch number, mix ratio by volume, product expiration date, ANSI hazard classification, and appropriate ANSI handling precautions.

C. Manufacturers: One of the following or equal:
   2. Simpson Strong-Tie Co., Inc., SET-XP.

2.03 REINFORCING BARS

A. As specified in Section E03200 - Concrete Reinforcing.

PART 3 EXECUTION

3.01 GENERAL

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

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

C. Install reinforcing bars and all thread rods to embedment depth, and at spacing and locations indicated on the Drawings.
   1. If embedment depth is not indicated, contact Engineer for requirements.
   2. Do not install adhesive-bonded all thread rods or reinforcing bars in upwardly inclined or overhead applications unless accepted in advance by Engineer.

3.02 PREPARATION

A. Do not begin installation of adhesive bonded anchors until:
   1. Concrete has achieved an age of at least 21 days after placement.
2. On-site training in installation of adhesive bonded anchors by manufacturer's technical representative is complete. Do not drill holes in concrete or install adhesive and embeds in holes.

B. Review manufacturer's printed installation instructions (MPII) and "conditions of use" stipulated in the Evaluation Report before beginning work.
   1. Bring to the attention of the adhesive manufacturer's technical representative any discrepancies between these documents, and resolve before proceeding with installation.

C. Install adhesive bonded anchors in full compliance with manufacturer's printed installation instructions using personnel who have successfully completed manufacturer's on-site training for products to be used and who hold certifications specified in this Section.

D. Confirm that adhesive and substrate receiving adhesive are within manufacturer's recommended range for temperature and moisture conditions, and will remain so during the curing time for the product.

3.03 HOLE SIZING AND INSTALLATION

A. Drilling holes:
   1. Determine location of reinforcing bars or other obstructions with a nondestructive indicator device, and mark locations with construction crayon on the surface of the concrete.
   2. Do not damage or cut existing reinforcing bars, electrical conduits, or other items embedded in the existing concrete without prior acceptance by Engineer.

B. Hole drilling equipment:
   1. Electric or pneumatic rotary impact type with medium or light impact.
      a. Installation of anchors in cored holes is not permitted.
      b. Set drill to "rotation only" mode, or to "rotation plus hammer" mode in accordance with the manufacturer's installation instructions and the requirements of the Evaluation Report.
      c. Where edge distances are less than 2 inches and "rotation plus hammer" mode is permitted, use lighter impact equipment to prevent micro-cracking and concrete spalling during the drilling process.
   2. Drill bits: Carbide-tipped in accordance with ANSI B212-15 unless otherwise recommended by the manufacturer or required as a "condition of use" in the Evaluation Report.
      a. Hollow drill bits with flushing air systems are preferred. Air supplied to hollow drill bits shall be free of oil, water, or other contaminants that will reduce bond.
C.  Hole diameter: As recommended in the manufacturer's installation instructions and the Evaluation Report.

D.  Hole depth: As recommended in the manufacturer's installation instructions to provide minimum effective embedment indicated on the Drawings.

E.  Obstructions in drill path:
1.  If an existing reinforcing bar or other obstruction is hit while drilling a hole, unless otherwise accepted by Engineer, stop drilling. Prepare and fill the hole with dry-pack mortar. Relocate the hole to miss the obstruction and drill another hole to the required depth.
   a.  Obtain Engineer’s acceptance of distance between abandoned and relocated holes before proceeding with the relocation.
   b.  Allow dry-pack mortar to cure to a strength equal to that of the surrounding concrete before resuming drilling in the area.
   c.  Epoxy grout may be substituted for dry-pack mortar when accepted by Engineer.
2.  Avoid drilling an excessive number of holes in an area of a structural member, which would excessively weaken the member and endanger the stability of the structure.
3.  When existing reinforcing steel is encountered during drilling and when specifically accepted by Engineer, enlarge the hole by 1/8 inch, core through the existing reinforcing steel at the larger diameter, and resume drilling at original hole diameter using pneumatic rotary impact drill.
4.  Bent bar reinforcing bars: Where edge distances are critical, and interference with existing reinforcing steel is likely, if acceptable to Engineer, drill hole at 10 degree (or less) angle from axis of reinforcing bar or all thread rod being installed.

F.  Cleaning holes:
1.  Insert air nozzle to bottom of hole and blow out loose dust.
   a.  Use compressed air that is free of oil, water, or other contaminants that will reduce bond.
   b.  Provide minimum air pressure of 90 pounds per square inch for not less than 4 seconds.
2.  Using a stiff bristle brush with diameter that provides contact around the full perimeter of the hole, vigorously brush hole to dislodge compacted drilling dust.
   a.  Insert brush to the bottom of the hole and withdraw using a simultaneous twisting motion.
   b.  Repeat at least 4 times.
3.  Repeat the preceding steps as required to remove drilling dust or other material that will reduce bond, and in the number of cycles required by the MPII and the Evaluation Report.
4.  Leave prepared holes clean and dry.
5. Protect prepared and cleaned holes from contamination and moisture until adhesive is installed.
6. Re-clean and dry previously prepared holes if, in the opinion of the Engineer, the hole has become contaminated after initial cleaning.

3.04 INSTALLATION OF ADHESIVE AND INSERTS

A. Clean and prepare inserts reinforcing bars and all thread rods:
   1. Prepare embedded length of reinforcing bars and all thread rods by cleaning to bare metal. Inserts shall be free of oil, grease, paint, dirt, mill scale, rust, or other coatings that will reduce bond.
   2. Solvent clean prepared reinforcing bars and all thread rods over the embedment length in accordance with SSPC SP-1. Provide an oil and grease free surface for bonding of adhesive to steel.

B. Fill holes with adhesive:
   1. Starting at the bottom of the hole, fill hole with adhesive inserting the reinforcing bar or all thread rod.
   2. Fill hole as nozzle is withdrawn without creating air voids.
   3. Unless otherwise indicated on the Drawings, fill hole with sufficient adhesive so that excess adhesive is extruded out of the hole when the reinforcing bar or all thread rod is inserted.
   4. Where necessary, seal hole at surface of concrete to prevent loss of adhesive during curing.

C. Installing reinforcing bars and all thread rods.
   1. Unless otherwise indicated on the Drawings, install bars and rods perpendicular to the concrete surface.
   2. Insert reinforcing bars and all thread rods into adhesive in accordance with manufacturer's recommended procedures.
   3. Confirm that insert has reached the designated embedment in the concrete, and that adhesive completely surrounds the embedded portion.
   4. Securely brace bars and all thread rods in place to prevent displacement while the adhesive cures. Bars and rods displaced during curing will be considered damaged and replacement will be required.
   5. Clean excess adhesive from the mouth of the hole.

D. Curing and loading.
   1. Provide and maintain curing conditions recommended by the adhesive manufacturer for the period required to fully cure the adhesive at the temperature of the concrete.
   2. Do not disturb or load bonded embeds until manufacturer's recommended cure time, based on temperature of the concrete, has elapsed.
3.05 POST-INSTALLATION ACTIVITIES

A. Do not bend bars or all-thread rods after bonding to the concrete, unless accepted in advance by the Engineer.

B. Attachments to all thread rods:
   1. After assemblies to be connected are placed, install nuts and washers for threaded rods as indicated on the Drawings.
   2. Draw nuts down tight, using practices specified for "snug tight" installation of bolts in steel to steel connections.

3.06 FIELD QUALITY CONTROL

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

B. Do not allow work described in this Section to be performed by individuals who do not hold the specified certifications and who have not completed the specified job site training.

C. Manufacturer's services:
   1. Before beginning installation, furnish adhesive manufacturer's technical representative to conduct on-site training in proper storage and handling of adhesive, drilling and cleaning of holes, and preparation and installation of reinforcing bars and all thread rods.
      a. Provide notice of scheduled training to Engineer and to Special Inspector(s) not less than 10 working days before training occurs. Engineer and Special Inspector may attend training sessions.
   2. Submit record, signed by the manufacturer's technical representative, listing Contractor's personnel who completed the training. Only qualified personnel who have completed manufacturer's on-site training shall perform installations.

D. Field inspections and testing:
   2. Results: Submit records of inspections and testing to Engineer by electronic copies within 24 hours after completion.

3.07 FIELD QUALITY ASSURANCE

A. Provide field quality assurance over the Work of this Section as specified in Section 01450 - Quality Control.

B. Special inspections, special tests, and structural observation:
   1. Provide as specified in Section 01455B - Special Tests and Inspections.
2. Frequency of inspections:
   a. Unless otherwise indicated on the Drawings or in this Section, provide periodic special inspection as required by the Evaluation Report for the product installed.
   b. Provide continuous inspection for the initial installation of each type and size of adhesive bonded reinforcing bar and all thread rod. Subsequent installations of the same anchor may be installed with periodic inspection as defined in subsequent paragraphs.
   c. Provide continuous inspection of all drilling, cleaning and bonding activities for bars and rods installed in horizontal an upwardly inclined positions.

3. Preparation:
   a. Review Drawings and Specifications for the Work to be observed.
   b. Review adhesive manufacturer’s MPII and recommended installation procedures.
   c. Review Evaluation Report "Conditions of Use" and "Special Inspection" requirements.

4. Inspection: Periodic:
   a. Initial inspection. Provide an initial inspection for each combination of concrete and reinforcing bar strength or concrete strength and all thread rod material being installed. During initial inspection, observe the following for compliance with the installation requirements.
      1) Concrete: Class (minimum specified compressive strength) and thickness.
      2) Environment: Temperature conditions at work area, and moisture conditions of concrete and drilled hole.
      3) Holes: Locations, spacing, and edge distances; verification of drill bit compliance with requirements; cleaning equipment and procedures; cleanliness of hole. Before adhesive is placed, confirm that depth and preparation of holes conforms to the requirements of the Contract Documents, the MPII, and the "conditions of use" listed in the Evaluation Report.
      4) Adhesive: Product manufacturer and name; lot number and expiration date; temperature of product at installation; installation procedure. Note initial set times observed during installation.
      5) Reinforcing bars and all thread rods: Material diameter and length; steel grade and/or strength; cleaning and preparation; cleanliness at insertion; minimum effective embedment provided.
   b. Subsequent inspections: Subsequent installations of the same reinforcing bars or all thread rods may be performed without the presence of the special inspector, provided that:
      1) There is no change in personnel performing the installation, the general strength and characteristics of the concrete receiving the inserts, or the reinforcing bars and all thread rods being used.
2) For ongoing installations, the special inspector visits the site at least once per day during each day of installation to observe the work for compliance with material requirements and installation procedures.

5. Inspection: Continuous.
   a. Make observations as described under "Inspection - Periodic, Initial Inspection" during all drilling, cleaning, and bonding activities for all bars and rods installed.

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

END OF SECTION
SECTION 03071
EPOXIES

PART 1 GENERAL

1.01 SUMMARY

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

1.02 REFERENCES

A. ASTM International (ASTM):
   2. C882 - Standard Test Method for Bond Strength of Epoxy-Resin Systems Used with Concrete by Slant Shear.

1.03 SYSTEM DESCRIPTION

A. Performance requirements:
   1. Provide epoxy materials that are new.
   2. Store and use products within limitations set forth by manufacturer.
   3. Perform and conduct work of this Section in neat orderly manner.

1.04 SUBMITTALS

A. General: Submit as specified in General Conditions.

B. Product Data: Submit manufacturer's data completely describing epoxy materials:
   1. Submit evidence of conformance to ASTM C881. Include manufacturer’s designations of Type Grade, Class, and Color.
   2. Submit documentation that materials meet or exceed the specified strength and performance characteristics. Indicate test methods and test results.

C. Quality control submittals:
   1. Manufacturer's installation instructions.
PART 2  PRODUCTS

2.01  MATERIALS

A.  General:
   1.  Moisture tolerant, water-insensitive, two-component epoxy resin adhesive material containing 100 percent solids, and meeting or exceeding the performance properties specified when tested in accordance with the standards specified.

B.  Epoxy: Low viscosity product in accordance with ASTM C881; Types I, II and IV; Grade 1; Class C.
   1.  Manufacturers: One of the following or equal:
       a.  Dayton Superior, Sure Inject J56.
       b.  Sika Corporation, Sikadur 35 Hi-Mod LV.
   2.  Required properties:

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Required Results (“neat”)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile Strength (7-day)</td>
<td>ASTM D638</td>
<td>7,100 pounds per square inch, minimum.</td>
</tr>
<tr>
<td>Compressive Strength (7-day)</td>
<td>ASTM D695</td>
<td>11,000 pounds per square inch, minimum.</td>
</tr>
<tr>
<td>Bond Strength (2-day)</td>
<td>ASTM C882</td>
<td>1,500 pounds per square inch, minimum. Concrete failure before failure of epoxy.</td>
</tr>
<tr>
<td>Viscosity (mixed)</td>
<td></td>
<td>250-550 centipoise</td>
</tr>
</tbody>
</table>

Notes:
(1)  Testing results are for materials installed and cured at a temperature between 72 and 78 degrees Fahrenheit for 7 days, unless otherwise noted.

C.  Epoxy gel: Non-sagging product in accordance with ASTM C881, Types I and IV, Grade 3, Class C.
   1.  Manufacturers: One of the following or equal:
       b.  Sika Corp., Sikadur 31, Hi-Mod Gel.
2. Required properties:

<table>
<thead>
<tr>
<th>Table 2 - Material Properties - Epoxy Gel(1)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Property</strong></td>
</tr>
<tr>
<td>Tensile Strength (7-day)</td>
</tr>
<tr>
<td>Compressive Yield Strength (7-day)</td>
</tr>
<tr>
<td>Bond Strength (14-day)</td>
</tr>
</tbody>
</table>

**Notes:**
(1) Testing results are for materials installed and cured at a temperature between 72 and 78 degrees Fahrenheit for 7 days, unless otherwise noted.

D. Epoxy bonding agent: Non-sagging product in accordance with ASTM C881, Type II, Grade 2, Class C.

1. Manufacturers: One of the following or equal:
   a. BASF, MasterEmaco ADH 326.
   b. Dayton Superior, Sure Bond J58.
   c. Sika Chemical Corp., Sikadur 32 Hi-Mod LPL.

2. Required properties.

<table>
<thead>
<tr>
<th>Table 3 - Material Properties - Epoxy Bonding Agent(1)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Property</strong></td>
</tr>
<tr>
<td>Tensile Strength (7-day)</td>
</tr>
<tr>
<td>Compressive Yield Strength (7-day)</td>
</tr>
<tr>
<td>Bond Strength (14-days)</td>
</tr>
<tr>
<td>Pot Life</td>
</tr>
</tbody>
</table>

**Notes:**
(1) Testing results are for materials installed and cured at a temperature between 72 and 78 degrees Fahrenheit for 7 days, unless otherwise noted.
3. If increased contact time is required for concrete placement, epoxy resin/portland cement bonding agent as specified in Section 03072 - Epoxy Resin/Portland Cement Bonding Agent may be used instead of epoxy bonding agent.

PART 3 EXECUTION

3.01 INSTALLATION

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

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

C. Epoxy gel:
   1. Apply in accordance with manufacturer's installation instructions.
   2. Use for vertical or overhead work, or where high viscosity epoxy is required.
   3. Epoxy gel used for vertical or overhead work may be used for horizontal work.

D. Epoxy bonding agent:
   1. Apply in accordance with manufacturer's installation instructions.
   2. Bonding agent will not be required for filling form tie holes or for normal finishing and patching of similar sized small defects.

END OF SECTION
SECTION 03072

EPOXY RESIN/PORTLAND CEMENT BONDING AGENT

PART 1       GENERAL

1.01       SUMMARY

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

1.02       REFERENCES

A. ASTM International (ASTM):

B. Federal Highway Administration (FHWA):

PART 2       PRODUCTS

2.01       MANUFACTURERS

A. Sika Corp., Sika Armatec 110.

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

A. Epoxy resin/portland cement adhesive:
   1. Component "A" shall be an epoxy resin/water emulsion containing suitable viscosity control agents. It shall not contain butyl glycidyl ether.
   2. Component "B" shall be primarily a water solution of a polyamine.
   3. Component "C" shall be a blend of selected portland cements and sands.
   4. The material shall not contain asbestos.

2.03 PERFORMANCE CRITERIA

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

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

PART 3 EXECUTION

3.01 INSTALLATION

A. Mixing the epoxy resin: Shake contents of Component "A" and Component "B." Empty all of both components into a clean, dry mixing pail. Mix thoroughly for 30 seconds with a jiffy paddle on a low-speed with 400 to 600 revolutions per minute drill. Slowly add the entire contents of Component "C" while continuing to mix for a minimum of 3 minutes and until uniform with no lumps. Mix only the quantity that can be applied within its pot life.
B. Placement procedure:
   1. Apply to prepared surface with stiff-bristle brush, broom, or "hopper-type" spray equipment:
      a. For hand applications: Place fresh plastic concrete/mortar while the bonding bridge adhesive is wet or dry, up to 24 hours.
      b. For machine applications: Allow the bonding bridge adhesive to dry for 12 hours minimum.

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

3.02 CLEANING

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

END OF SECTION
SECTION 03150
CONCRETE ACCESSORIES

PART 1  GENERAL

1.01  SUMMARY

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

1.02  REFERENCES

A. ASTM International (ASTM):

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

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

1.03  SUBMITTALS

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

B. Samples:
   1. Polyvinyl chloride waterstop.

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

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

1.04 QUALITY ASSURANCE

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

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

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

PART 2  PRODUCTS

2.01 JOINT FILLERS

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

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

2.02 WATERSTOPS

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

<table>
<thead>
<tr>
<th>Physical Characteristics</th>
<th>Test Method</th>
<th>Required Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Gravity</td>
<td>ASTM D792</td>
<td>Not less than 1.3.</td>
</tr>
<tr>
<td>Hardness</td>
<td>ASTM D2240</td>
<td>70 to 90 Type A15 Shore durometer.</td>
</tr>
<tr>
<td>Tensile Strength</td>
<td>ASTM D638</td>
<td>Not less than 2,000 pounds per square inch.</td>
</tr>
<tr>
<td>Ultimate Elongation</td>
<td>ASTM D638</td>
<td>Not less than 300 percent.</td>
</tr>
<tr>
<td>Alkali Extraction</td>
<td>CRD-C-572</td>
<td>Change in weight after 7 days: Between minus 0.1 percent and plus 0.25 percent.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Change in hardness after 7 days: Not more than plus 5 points.</td>
</tr>
<tr>
<td>Low Temperature Brittle Point</td>
<td>ASTM D746</td>
<td>No sign of cracking or chipping at -35 degrees Fahrenheit.</td>
</tr>
<tr>
<td>Water Absorption</td>
<td>ASTM D570</td>
<td>Not more than 0.15 percent after 24 hours.</td>
</tr>
<tr>
<td>Accelerated Extraction Test</td>
<td>CRD-C-572</td>
<td>Tensile strength: Not less than 1,600 pounds per square inch.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Elongation: Not less than 280 percent.</td>
</tr>
<tr>
<td>Stiffness in Flexure</td>
<td>ASTM D747</td>
<td>Not less than 600 pounds per square inch.</td>
</tr>
<tr>
<td>Tear Resistance</td>
<td>ASTM D624</td>
<td>Not less than 225 pounds per inch.</td>
</tr>
<tr>
<td>Thickness</td>
<td>-</td>
<td>3/8 inch.</td>
</tr>
<tr>
<td>Center Bulb</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6-inch Waterstops</td>
<td>-</td>
<td>7/8 inch or 1-inch nominal outside diameter.</td>
</tr>
<tr>
<td>9-inch Waterstops</td>
<td>-</td>
<td>For expansion joints 1 inch and narrower: 1-inch nominal outside diameter.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>For expansion joints wider than 1 inch: 2-inch nominal outside diameter.</td>
</tr>
<tr>
<td>Allowable Tolerances</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Width</td>
<td>-</td>
<td>Plus or minus 3/16 inch.</td>
</tr>
<tr>
<td>Thickness</td>
<td>-</td>
<td>Plus or minus 1/32 inch.</td>
</tr>
</tbody>
</table>

B. Waterstops - hydrophilic rubber.
PART 3 EXECUTION

3.01 INSTALLATION

A. Waterstops:
   1. General:
      a. Store waterstops so as to permit free circulation of air around waterstop material and prevent direct exposure to sunlight.
      b. Install waterstops in concrete joints where indicated on the Drawings.
      c. Carry waterstops in walls into lower slabs and join to waterstops in slabs with appropriate types of fittings.
      d. In waterbearing structures: Provide all joints with waterstops, whether indicated on the Drawings or not.
      e. Provide waterstops that are continuous.
      f. Set waterstops accurately to position and line as indicated on the Drawings.
      g. Hold and securely fix edges in position at intervals of not more than 24 inches so that they do not move during placing of concrete.
      h. Position the waterstop so that symmetrical halves of waterstop are equally divided between concrete pours. Center axis of waterstop shall be coincident with centerline of the joint.
      i. Do not drive nails, screws, or other fasteners through waterstops in vicinity of construction joints.
      j. Use wires at not more than 24 inches on centers near outer edge of waterstop to tie waterstops into position.
      k. Special clips may be used in lieu of wires, at Contractor's option.
      l. Terminate waterstops 3 inches from top of finish surfaces of walls and slabs unless otherwise specified or indicated on the Drawings.
      m. When any waterstop is installed in concrete on one side of joint, while the other half or portion of the waterstop remains exposed to the atmosphere for more than 2 days, take suitable precautions to shade and protect exposed waterstop from direct rays of sunlight during entire exposure and until exposed portion is embedded in concrete.
      n. When placing concrete at waterstops in slabs, lift edge of waterstop while placing concrete below the waterstop. Manually force waterstop against and into concrete, and then cover waterstop with fresh concrete.

   2. Polyvinyl chloride waterstop:
      a. Install waterstops so that joints are watertight.
      b. Weld joints such as unions, crosses, ells, and tees, with thermostatically controlled equipment recommended by waterstop manufacturer:
         1) Do not damage material by heat sealing.
         2) Make joints by overlapping, then simultaneously cut ends of sections to be spliced so they will form smooth even joint. Heat cut ends with splicing tool until the plastic melts. Press 2 ends together until plastic cools.
3) Maintain continuity of waterstop ribs and tubular center axis.
4) The splices shall have tensile strength of not less than 60 percent of unspliced materials tensile strength.
c. Butt joints of ends of 2 identical waterstop sections may be made while material is in forms.
d. Prefabricate waterstop joints involving more than 2 butt ends to be joined together, including all joints that involve an angle cut, alignment change, or joining of 2 dissimilar waterstop sections, prior to placement in form.
   1) Provide not less than 24-inch long strips of waterstop material beyond joint.
   2) After inspection and acceptance, install such prefabricated waterstop joint assemblies in forms and butt-weld ends of 24-inch strips to straight run portions of waterstop in place in forms.
e. Manufacturer shall factory prefabricate joints for crosses and tees.
f. Split-type waterstops will not be permitted except where specifically indicated on the Drawings.

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

END OF SECTION
SECTION 03154
HYDROPHILIC RUBBER WATERSTOP

PART 1   GENERAL

1.01 SUMMARY

A. Section includes: Hydrophilic rubber waterstop.

1.02 SUBMITTALS

A. General:
   1. Submit the following items for each type, style and size of hydrophilic waterstop to be installed.
   2. Product data:
      a. Manufacturer’s product data sheets.
         1) Include complete physical dimensions, expansion characteristics, and laboratory test reports indicating that average material properties conform to the requirements specified.
         2) Provide data sheets for all materials to be included in the waterstop system.
   3. Samples:
      a. Minimum 6-inch long samples of each type of waterstop to be used if requested by the Engineer.
   4. Manufacturer's installation instructions:
      a. Installation instructions and recommended installation details for the complete waterstop system, and for each component used in that system.

PART 2   PRODUCTS

2.01 HYDROPHILIC RUBBER WATERSTOP

A. General:
   1. System composed of flexible hydrophilic urethane polymer with preformed strips, adhesives, paste, fasteners, and other accessories required for a complete and watertight installation.
      a. To ensure compatibility of materials, a single manufacturer shall provide all products and accessories for the hydrophilic waterstop system.
      b. Products incorporating bentonite are not acceptable under this Section.
      c. Provide waterstop and accessories resistant to degradation under cyclic wetting and drying.
2. Manufacturers: One of the following or equal:
   a. Hydrophilic strip: Adeka Ultra Seal USA: MC-2010MN.
   b. Low expansion hydrophilic strip: Adeka Ultra Seal USA: KBA-1510FP.

B. Hydrophilic paste waterstop.
   1. Single-component gun grade paste of hydrophilic rubber designed to undergo controlled expansion when exposed to moisture after initial curing.
   2. Manufacturers: One of the following or equal:
      a. Adeka Ultra Seal USA: P-201.
      b. Sika Corp., Leakmaster LV-Z.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install products in accordance with manufacturer’s instructions and recommended details.

B. Prepare concrete joint surfaces:
   1. Use wire brushing or scraping to expose an uncontaminated, solid surface.
   2. Clean prepared surface with high-pressure air or water to remove residue and debris.
   3. Confirm that prepared surfaces conform to manufacturer’s recommendations for surface profile and moisture conditions before installing materials.

C. Provide manufacturer’s recommended lap, splice, and corner details for hydrophilic waterstops.
   1. Use hydrophilic paste at all corner joints and overlap splices of hydrophilic strips.

D. Hydrophilic strip waterstop:
   1. Install primers and adhesives when recommended by the manufacturer before setting hydrophilic strips.
   2. Keep hydrophilic strip taut during the fastening process.
   3. Secure hydrophilic strip in place with concrete nails, screws, or adhesive.
   4. Provide installation with no gap between the hydrophilic strip and the concrete to which it is attached. At rough or irregular surfaces, set hydrophilic strip waterstop strip in a bead of hydrophilic paste.
      a. Fill all voids and rough areas under the hydrophilic strip with hydrophilic paste.
      b. Allow hydrophilic paste to cure in accordance with manufacturer’s recommendations before encapsulating paste in fresh concrete.
3.02 SCHEDULE

A. At the following joint locations/conditions, use the hydrophilic strip waterstop configuration noted unless otherwise indicated on the Drawings.

B. Concrete construction joints:
   1. Under all of the following conditions, use hydrophilic strip waterstop set in a bed of hydrophilic paste waterstop, and screw strip waterstop to concrete surface:
      a. Slab or wall thickness is greater than 10 inches.
      b. Waterstop is placed between 2 rows of steel reinforcement.
      c. Concrete cover from waterstop to nearest concrete face is at least 4 inches.
   2. Under any one of the following conditions, use low-expansion hydrophilic strip waterstop set in bed of hydrophilic paste waterstop and screw strip to concrete surface:
      a. Waterstop is placed on 1 side of a single row of steel reinforcement.
      b. Concrete cover from waterstop to nearest concrete face is less than 4 inches.

C. Pipe penetrations through concrete:
   1. Pipe diameter less than 4 inches: Not allowed.
   2. Pipe diameter of 4 to 24 inches: Continuous bead of hydrophilic paste waterstop, minimum 1/4-inch high by 1/2-inch wide, encircling pipe.
   3. Pipe diameter greater than 24 inches: Continuous hydrophilic strip waterstop around perimeter of pipe, with hydrophilic paste seal at lapped ends of strip.

END OF SECTION
SECTION 03366
TOOLED CONCRETE FINISHING

PART 1   GENERAL

1.01  SUMMARY

A. Section includes: Tooled concrete finishes.

1.02  QUALITY ASSURANCE

A. Mock-ups:
   1. Test panels for concrete finishes:
      a. Prepare test panels for F4 and F5 finishes and tie-hole repairs for review by Engineer.
      b. Accepted test panels serve as standard of quality and workmanship for project.
   2. Prepare test panel showing horizontal and vertical joints proposed for project for review by the Engineer. Refer to finishes specified in this Section.
   3. Test panels indicating methods for making concrete repairs: Prepare test panels for proposed repairs at beginning of project for review by Engineer:
      a. Accepted test panels serve as standard for repairs during the project.

1.03  DELIVERY, STORAGE, AND HANDLING

A. Packing and shipping:
   1. Deliver and store packaged materials in original containers until ready for use.

PART 2   PRODUCTS

2.01  MIXES

A. Mortar mix for F4 finish: Consist of 1 part cement and 1-1/2 parts of fine sand passing Number 100 screen. Mix with enough water and emulsified bonding agent to have consistency of thick cream.

B. Mortar mix for F5 finish: Consist of 1 part cement to 1-1/2 parts of sand which passes Number 16 screen.
PART 3   EXECUTION

3.01 CONCRETE FINISHES

A. Cement for finishes:
   1. Addition of white cement may be required to produce finish which matches color of concrete to be finished.

B. Finish vertical concrete surfaces with one of the following finishes as indicated in the Finish Schedule:
   1. F1 finish: No special treatment other than repair defective work and fill depressions 1 inch or deeper and tie holes with mortar after removal of curing compound.
   2. F2 finish: No special treatment other than repair defective work, remove fins, fill depressions 1/2 inch or deeper and tie holes with mortar after removal of curing compound.
   3. F3 finish: Repair defective work, remove fins, offsets, and grind projections smooth. Fill depressions 1/4 inch or larger in depth or width and tie holes with mortar after removal of curing compound.
   4. F4 finish: Receive same finish as specified for F3 finish, and, in addition fill depressions and holes 1/16 inch or larger in width with mortar.
      a. "Brush-Off" sandblast surfaces prior to filling holes to expose all holes near surface of the concrete.
      b. Thoroughly wet surfaces and commence filling of pits, holes, and depressions while surfaces are still damp.
      c. Perform filling by rubbing mortar over entire area with clean burlap, sponge rubber floats, or trowels.
      d. Do not let any material remain on surfaces, except that within pits and depressions.
      e. Wipe surfaces clean and moist cure.
   5. F5 finish: Receive same finish as specified for F3 finish, and, in addition, receive special stoned finish, in accordance with following requirements:
      a. Remove forms and perform required repairs, patching, and pointing as specified in this Section.
      b. Wet surfaces thoroughly with brush and rub with hard wood float dipped in water containing 2 pounds of portland cement per gallon.
      c. Rub surfaces until form marks and projections have been removed.
      d. Spread grindings from rubbing operations uniformly over surface with brush in such manner as to fill pits and small voids.
      e. Moist cure brushed surfaces and allow to harden for 3 days:
         1) After curing, obtain final finish by rubbing with carborundum stone of approximately Number 50 grit until entire surfaces have smooth texture and are uniform in color.
         2) Continue curing for remainder of specified time.
f. If any concrete surface is allowed to become too hard to finish in above specified manner, sandblast and wash related surfaces exposed to view, whether finished or not.

1) While still damp, rub over surface, plastic mortar, as specified for brushed surfaces and handstoned with Number 60 grit carborundum stone, using additional mortar for brushed surfaces until surface is evenly filled without an excess of mortar.

2) Continue stoning until surface is hard.

3) After moist curing for 3 days, make surface smooth in texture and uniform in color by use of Number 50 or Number 60 grit carborundum stone.

4) After stoning, continue curing until 7 day curing period is completed.

C. Finish horizontal concrete surfaces with one of the following finishes as indicated in the Finish Schedule after proper and adequate vibration and tamping:

1. S1 finish: Screeded to grade and leave without special finish.

2. S2 finish: Smooth steel trowel finish.

3. S3 finish: Steel trowel finish free from trowel marks. Provide smooth finish free of all irregularities.

4. S4 finish: Steel trowel finish, without local depressions or high points, followed by light hairbroom finish. Do not use stiff bristle brooms or brushes. Perform brooming parallel to slab-drainage. Provide resulting finish that is rough enough to provide nonskid finish. Finish is subject to review and acceptance by the Engineer.

5. S5 finish: Nonslip abrasive: After concrete has been screeded level and hardened enough to support man standing on a board, sprinkle abrasive from shake screen into surface at uniform rate of 25 pounds for each 100 square feet of surface area, wood float into finish, then trowel abrasive into surface with steel trowel properly exposing abrasive in surface as required to provide nonslip surface.

6. S6 finish: Roughened finish: After concrete has been screeded to grade, apply a roughened finish by use of a jitterbug roller or similar device.

D. Finish concrete floor surfaces to which surfacing material is applied: Finish smooth with tolerance within 1/8 inch in 10 feet in any direction from lines indicated on the Drawings.

3.02 CONCRETE FINISH SCHEDULE

A. Finish concrete surfaces as follows:

1. F4 finish for following vertical surfaces:
   a. Concrete surfaces specified or indicated to be painted.
   b. Concrete surfaces, interior or exterior, exposed to view.

2. Surfaces in open channels, basins, and similar structures:
   a. F3 finish for vertical surfaces which are normally below water surface.
b. F4 finish for vertical surfaces located above normal water surface and exposed to view.

c. Remove fins and fill tie holes from concrete surfaces located in closed boxes or channels where there is normally no access or passageway.

3. S1 finish for following surfaces:
   a. Projecting footings which are to be covered with dirt.
   b. Slab surfaces which are to be covered with concrete fill.

4. S2 finish for following surfaces:
   a. Tops of corbels.
   b. Tops of walls and beams not covered above in this Section.
   c. Tops of slabs not covered above in this Section.
   d. All other surfaces not specified to be finished otherwise.

5. S3 finish for following surfaces:
   a. Building and machine room floors which are not covered with surfacing material: Provide floors that are free from trowel marks.

6. S4 finish for following surfaces:
   a. Exterior walkways.
   b. Tops of exterior walls or beams which are to serve as walkways.
   c. Tops of exterior walls or beams which are to support gratings.
   d. Top surface of slabs for basins, channels, digesters, and similar structures.

7. S6 finish for following surfaces:
   a. Basin bottoms, or other similar slab surfaces, over which layer of basin bottom grout will be applied.

END OF SECTION
SECTION 03600
GROUTING

PART 1  GENERAL

1.01  SUMMARY

A. Section includes:
   1. Cement grout.
   2. Cement mortar.
   3. Dry-pack mortar.
   4. Epoxy grout.
   5. Grout.
   7. Non-shrink grout.

1.02  REFERENCES

A.  ASTM International (ASTM):

B.  International Concrete Repair Institute (ICRI):
   1. 310.2R - Selecting and specifying Concrete Surface Preparations for Sealers, Coatings, Polymer Overlays, and Concrete Repair.
1.03 SUBMITTALS

A. Cement grout:
   1. Mix design.

B. Cement mortar:
   1. Mix design.

C. Non-shrink epoxy grout:
   1. Manufacturer’s literature.

D. Non-shrink grout:
   1. Manufacturer’s literature.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to jobsite in their original, unopened packages or containers, clearly labeled with manufacturer's product identification and printed instructions.

B. Store materials in cool dry place and in accordance with manufacturer's recommendations.

C. Handle materials in accordance with the manufacturer's instructions.

PART 2 PRODUCTS

2.01 MANUFACTURED UNITS

A. Non-shrink epoxy grout:
   1. Manufacturers: One of the following or equal:
      b. BASF Construction Chemicals, Masterflow 648 CP Plus.
      c. L&M Construction Chemicals, Inc., EPOGROUT.
   2. Non-shrink epoxy grout shall be 100 percent solid, premeasured, prepackaged system containing 2-component thermosetting epoxy resin and inert aggregate.
   3. Maintain flowable consistency for at least 45 minutes at 70 degrees Fahrenheit.
   4. Shrinkage or expansion: Less than 0.0006 inches per inch when tested in accordance with ASTM C531.
   5. Minimum compressive strength: 10,000 pounds per square inch at 24 hours and 14,000 pounds per square inch at 7 days when tested in accordance with ASTM C579, Method B.
6. Compressive creep: Not exceed 0.0027 inches/per inch when tested under 400 pounds per square inch constant load at 140 degrees Fahrenheit in accordance with ASTM C1181.
7. Coefficient of thermal expansion: Not exceed 0.000018 inches per inch per degree Fahrenheit when tested in accordance with ASTM C531, Method B.

B. Non-shrink grout:
   1. Manufacturers: One of the following or equal:
      b. BASF Construction Chemicals, Masterflow 928.
      c. L&M Construction Chemicals, Inc., CRUXTEX.
   2. In accordance with ASTM C1107.
   3. Preportioned and prepackaged cement-based mixture.
   4. Contain no metallic particles such as aluminum powder and no metallic aggregate such as iron filings.
   5. Require only addition of potable water.
   7. Free from emergence of mixing water from within or presence of water on its surface.
   8. Remain at minimum flowable consistency for at least 45 minutes after mixing at 45 degrees Fahrenheit to 90 degrees Fahrenheit when tested in accordance with ASTM C230.
      a. If at fluid consistency, verify consistency in accordance with ASTM C939.
   9. Dimensional stability (height change):
      a. In accordance with ASTM C1107, volume-adjusting Grade B or C at 45 degrees Fahrenheit to 90 degrees Fahrenheit.
      b. Have 90 percent or greater bearing area under bases.
   10. Have minimum compressive strengths at 45 degrees Fahrenheit to 90 degrees Fahrenheit in accordance with ASTM C1107 for various periods from time of placement, including 5,000 pounds per square inch at 28 days when tested in accordance with ASTM C109 as modified by ASTM C1107.

2.02 MIXES

A. Cement grout:
   1. Use same sand-to-cementitious materials ratio for cement grout mix that is used for concrete mix.
   2. Use same materials for cement grout that are used for concrete.
   3. Use water-to-cementitious materials ratio that is no more than that specified for concrete.
   4. For spreading over surfaces of construction or cold joints.

B. Cement mortar:
   1. Use same sand-to-cementitious materials ratio for cement mortar mix that is used for concrete mix.
   2. Use same materials for cement mortar that are used for concrete.
3. Use water-to-cementitious materials ratio that is no more than that specified for concrete being repaired.

4. At exposed concrete surfaces not to be painted or submerged in water: Use sufficient white cement to make color of finished patch match that of surrounding concrete.

C. Dry-pack mortar:
   1. Proportions by weight: 1 part portland cement to 2 parts concrete sand.
      a. Portland cement: As specified in Section E03300 - Cast-in-Place Concrete.
      b. Concrete sand: As specified in Section E03300 - Cast-in-Place Concrete.

D. Epoxy grout:
   1. Consist of mixture of epoxy or epoxy gel and sand.
      a. Epoxy: As specified in Section 03071 - Epoxies.
      b. Epoxy gel: As specified in Section 03071 - Epoxies.
      c. Sand: Clean, bagged, graded, and kiln-dried silica sand.
   2. Proportioning:
      a. For horizontal work: Consist of mixture of 1 part epoxy with not more than 2 parts sand.
      b. For vertical or overhead work: Consist of 1 part epoxy gel with not more than 2 parts sand.

E. Grout:
   1. Mix in proportions by weight: 1 part portland cement to 4 parts concrete sand.
      a. Portland cement: As specified in Section E03300 - Cast-in-Place Concrete.
      b. Concrete sand: As specified in Section E03300 - Cast-in-Place Concrete.

F. Non-shrink epoxy grout:
   1. Mix in accordance with manufacturer's installation instructions.

G. Non-shrink grout:
   1. Mix in accordance with manufacturer's installation instructions such that resulting mix has flowable consistency and is suitable for placing by pouring.

PART 3 EXECUTION

3.01 EXAMINATION

A. Inspect concrete surfaces to receive grout or mortar and verify that they are free of ice, frost, dirt, grease, oil, curing compounds, paints, impregnations, and loose material or foreign matter likely to reduce bond or performance of grout or mortar.
3.02 PREPARATION

A. Surface preparation for grouting other baseplates:
   1. Remove grease, oil, dirt, dust, curing compounds, laitance, and other deleterious materials that may affect bond to concrete and bottoms of baseplates.
   2. Roughen concrete surfaces in contact with grout to ICRI CSP-6 surface profile or rougher.
      a. Remove loose or broken concrete.
   3. Metal surfaces in contact with grout: Grit blast to white metal surface.

3.03 INSTALLATION

A. Mixing:
   1. Cement grout:
      a. Use mortar mixer with moving paddles.
      b. Pre-wet mixer and empty out excess water before beginning mixing.
   2. Cement mortar:
      a. Use mortar mixer with moving paddles.
      b. Pre-wet mixer and empty out excess water before beginning mixing.
   3. Dry-patch mortar:
      a. Use only enough water so that resulting mortar will crumble to touch after being formed into ball by hand.
   4. Non-shrink epoxy grout:
      a. Keep temperature of non-shrink epoxy grout from exceeding manufacturer's recommendations.
   5. Non-shrink grout:
      a. May be dry packed, flowed, or pumped into place. Do not overwork grout.
      b. Do not retemper by adding more water after grout stiffens.

B. Placement:
   1. Cement grout:
      a. Exercise care in placing cement grout because it is required to furnish structural strength, impermeable water seal, or both.
      b. Do not use cement grout that has not been placed within 30 minutes after mixing.
   2. Cement mortar:
      a. Use mortar mixer with moving paddles.
      b. Pre-wet mixer and empty out excess water before beginning mixing.
   3. Epoxy grouts:
      a. Wet surfaces with epoxy for horizontal work or epoxy gel for vertical or overhead work prior to placing epoxy grout.
   4. Non-shrink epoxy grout:
      a. Mix in complete units. Do not vary ratio of components or add solvent to change consistency of mix.
b. Pour hardener into resin and mix for at least 1 minute and until mixture is uniform in color. Pour epoxy into mortar mixer wheelbarrow and add aggregate. Mix until aggregate is uniformly wetted. Over mixing will cause air entrapment in mix.

5. Non-shrink grout:
   a. Add non-shrink cement grout to premeasured amount of water that does not exceed the manufacturer's maximum recommended water content.
   b. Mix in accordance with manufacturer's instructions to uniform consistency.

C. Curing:
   1. Cement based grouts and mortars:
      a. Keep continuously wet for minimum of 7 days. Use wet burlap, soaker hose, sun shading, ponding, and in extreme conditions, combination of methods.
      b. Maintain above 40 degrees Fahrenheit until it has attained compressive strength of 3,000 pounds per square inch, or above 70 degrees Fahrenheit for minimum of 24 hours to avoid damage from subsequent freezing.
   2. Epoxy based grouts:
      a. Cure grouts in accordance with manufacturers' recommendations.
         1) Do not water cure epoxy grouts.
      b. Do not allow any surface in contact with epoxy grout to fall below 50 degrees Fahrenheit for minimum of 48 hours after placement.

D. Grouting equipment bases, baseplates, soleplates, and skids: As specified in Section 15050 - Common Work Results for Mechanical Equipment.

E. Grouting other baseplates:
   1. General:
      a. Use non-shrink grout as specified in this Section.
      b. Baseplate grouting shall take place from one side of baseplate to other in continuous flow of grout to avoid trapping air in grout.
      c. Maintain hydrostatic head pressure by keeping level of grout in headbox above bottom of baseplate. Fill headbox to maximum level and work grout down.
      d. Vibrate, rod, or chain non-shrink grout to facilitate grout flow, consolidate grout, and remove trapped air.
   2. Forms and headboxes:
      a. Build forms using material with adequate strength to withstand placement of grouts.
      b. Use forms that are rigid and liquidtight. Caulk cracks and joints with elastomeric sealant.
      c. Line forms with polyethylene for easy grout release. Coating forms with 2 coats of heavy-duty paste wax is also acceptable.
d. Headbox shall be 4 to 6 inches higher than baseplate and shall be located on one side of baseplate.

e. After grout sets, remove forms and trim back grout at 45 degree angle from bottom edges of baseplate.

3.04 FIELD QUALITY CONTROL

A. Non-shrink epoxy grout:
   1. Test for 24-hour compressive strength in accordance with ASTM C579, Method B.

B. Non-shrink grout:
   1. Test for 24-hour compressive strength in accordance with ASTM C942.

END OF SECTION
SECTION 03931

EPOXY INJECTION SYSTEM

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Epoxy injection system.

1.02 REFERENCES

A. ASTM International (ASTM):
   2. C882 - Standard Test Method for Bond Strength of Epoxy-Resin Systems Used With Concrete by Slant Shear.

1.03 SUBMITTALS

A. General: Submit as specified in General Conditions.

B. Product data:
   1. Manufacturer's data completely describing epoxy injection system materials, and including test methods and results for strength in tension, flexure, compression and bond; flexural modulus of elasticity; coefficient of thermal expansion; and elongation.

C. Quality control submittals:
   1. Certificates of Compliance.
   2. Manufacturer's Instructions.

D. Special procedure submittals:
   1. Protection plan for surrounding areas and non-cementitious surfaces.

1.04 QUALITY ASSURANCE

A. Products:
   1. Provide materials that are new and use them within shelf life limitations set forth by manufacturer.
B. Qualifications:
   1. Installer:
      a. Minimum 5 years' experience in concrete repair, with focus on application of similar systems and products to projects of similar size and scope.

C. Pre-installation meeting:
   1. At least 1 week prior to commencing work of this Section, convene a meeting at the project site to review and discuss the following:
      a. Surface preparation.
      c. Installation procedures.
      d. Environmental conditions (including weather forecast) and curing requirements.
      e. Testing and inspection procedures.
      f. Protection of surrounding surfaces and equipment.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials in manufacturer's original, unopened, undamaged containers with identification labels intact. Labels shall include product identification, batch numbers, and shelf life information.

B. Store materials off the ground and away from moisture and direct sunlight, and at temperatures within manufacturer's recommended range.

C. Pre-condition materials to manufacturer's recommended temperatures before mixing and using.

1.06 PROJECT CONDITIONS

A. Take precautions to protect surfaces and equipment in the work area from damage and staining.

PART 2 PRODUCTS

2.01 MATERIALS

A. General:
   1. Repair materials shall be free of chlorides or alkalis (except for those attributed to water).
   2. To ensure compatibility of materials and methods, a single manufacturer shall produce and provide all products used together in a single area of concrete repair.
B. Manufacturers: One of the following or equal:
   1. BASF Building Systems, MasterInject 1500 (formerly Concresive Standard LVI).
   2. Sika Chemical Corp., Sikadur 35 Hi-Mod LV.

C. Epoxy:
   1. In accordance with ASTM C881, Types I, II and IV, Grade 1, Class C.
   2. Water-insensitive 2-component low viscosity, epoxy adhesive material containing 100 percent solids and meeting or exceeding following characteristics when tested in accordance with standards specified:

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Test Method</th>
<th>Required Results, minimum&lt;sup&gt;(1,2)&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viscosity (mixed)</td>
<td>--</td>
<td>250 - 375 centipoise</td>
</tr>
<tr>
<td>Tensile Strength</td>
<td>ASTM D638</td>
<td>7,500 pounds per square inch</td>
</tr>
<tr>
<td>Tensile Elongation at Break</td>
<td>ASTM D638</td>
<td>1 percent</td>
</tr>
<tr>
<td>Compressive Strength</td>
<td>ASTM D695</td>
<td>11,000 pounds per square inch</td>
</tr>
<tr>
<td>Compressive Modulus</td>
<td>ASTM D695</td>
<td>2.5 x 10&lt;sup&gt;5&lt;/sup&gt; pounds per square inch.</td>
</tr>
<tr>
<td>Bond Strength, slant shear, hardened concrete to hardened concrete</td>
<td>ASTM C882</td>
<td>1500 pounds per square inch at 2 days at minimum 73 degrees Fahrenheit. Concrete shall fail before failure of epoxy.</td>
</tr>
<tr>
<td>Heat Deflection Temperature</td>
<td>ASTM D648</td>
<td>124 degrees Fahrenheit</td>
</tr>
</tbody>
</table>

Notes:
(1) Properties for mixes with neat epoxy.
(2) Results after 7-day cure at temperature between 72 and 78 degrees Fahrenheit, unless otherwise noted.

2.02 EQUIPMENT

A. Injection pump:
   1. Use positive displacement injection pump with interlock to provide in-line mixing and metering system for 2 component epoxy.
   2. Use pressure hoses and injection nozzle designed to properly mix of 2 components of epoxy.
   3. Standby injection unit may be required.
PART 3 EXECUTION

3.01 PREPARATION

A. Surface preparation:
   1. Confirm that surface temperature and moisture conditions are within manufacturer's recommended limits. Condition surfaces to within those limits before commencing epoxy injection.
   2. Sweep or clean area in vicinity of cracks that will be injected with epoxy. Leave area in generally clean condition after epoxy injection is complete.
   3. Clean cracks so they are free from dirt, laitance, and other loose matter.

3.02 INSTALLATION

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

B. Mixing:
   1. Mix epoxy in accordance with manufacturer's installation instructions.
   2. Do not use solvents to thin epoxy system materials introduced into cracks or joints.

C. Injection:
   1. Apply adequate surface seal to crack to prevent leakage of epoxy.
   2. Establish injection points at distance along crack not less than thickness of cracked member.
   3. Crack injection sequence:
      a. Inject epoxy into crack or joint at first port with sufficient pressure to advance epoxy to adjacent port. Start at lowest port along the injection line and work upwards.
      b. Seal original port and shift injection to next adjacent port where epoxy appears.
      c. Continue port-to-port injection until crack has been injected for its entire length.
      d. For small amounts of epoxy, or where excessive pressure developed by injection pump might further damage structure, premixed epoxy and use hand caulking gun to inject epoxy if acceptable to the Engineer.
      e. Seal ports, including adjacent locations where epoxy seepage occurs, as necessary to prevent drips or run out.
      f. After epoxy injection is complete, remove surface seal material, and refinish concrete in area where epoxy was injected to match existing concrete. Leave finished work and work area in a neat, clean condition.

3.03 FIELD QUALITY ASSURANCE

A. Provide Contractor quality control as specified in Section 01450 - Quality Control.
B. Field inspections and testing:
   1. Submit records of inspections and tests to Engineer within 24 hours after completion.

C. Manufacturer's services.
   1. Pre-installation meeting: Provide manufacturer's technical representative to attend pre-installation meeting specified in this Section.

3.04 FIELD QUALITY CONTROL

A. Provide District's quality assurance for the Work of this Section as specified in Section 01450 - Quality Control.

B. Special inspections special tests, and structural observation:
   1. Not required.

C. Field inspections:
   1. Preparation:
      a. Review manufacturer's product data and installation instructions.
   2. Required inspections.
      a. Observe surfaces to be injected for temperature and moisture conditions and for surface preparation.
      b. Observe conditioning and mixing of epoxy resin components.
      c. Observe injection procedures for filling cracks.
   3. Records of inspections:
      a. Provide record of each inspection.
      b. Submit to Engineer upon request.

3.05 Non-conforming work

A. Rework surface finishes that do not match surrounding concrete to the satisfaction of Engineer at no additional cost to District.

END OF SECTION
SECTION 05120

STRUCTURAL STEEL

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Structural steel shapes and plate.
   2. Fasteners and structural hardware:
      a. All thread rods.
      b. High-strength bolts.
   3. Welding.

1.02 REFERENCES

A. American Institute of Steel Construction (AISC):
   1. 303 - Code of Standard Practice for Steel Buildings and Bridges.
   2. 360 - Specification for Structural Steel Buildings.

B. American Iron and Steel Institute (AISI):
   1. Steel and stainless steel alloys (“types”) as indicated.

C. American Welding Society (AWS):

D. ASTM International (ASTM):
   5. A194 - Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
   6. A500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.

E. Research Council on Structural Connections (RCSC):

1.03 DEFINITIONS

A. Snug-tight: At bolted joints, the tightness attained with a few impacts of an impact wrench, or by the full effort of an ironworker using a spud wrench to bring the connected plies into firm contact.

1.04 SUBMITTALS

A. Product data:
   1. Welding electrodes for field welds: Electrode manufacturer's data.

B. Shop drawings:
   1. Fabrication and erection drawings.

C. Quality control submittals:
   1. Welding procedure specifications (WPS) in accordance with AWS D1.6.
      a. Submit WPS for each type of welded joint used, whether prequalified or qualified by testing.
         1) State electrode manufacturer and specific electrodes used.
         2) Indicate required AWS qualification for joint.
      b. Submit WPS with shop drawings that indicate those welds.
      c. Submit Procedure Qualification Record (PQR) in accordance with AWS D1.6 for welding procedures qualified by testing.
   2. Welder qualifications: For each welding process and position:
      a. Welder's qualification certificates.
b. Contractor's statement that certificate will be "in effect" at the time(s) welding will be performed based on the "Period of Effectiveness" provisions of AWS D1.6.

D. Test reports:
   1. Certified copies of mill tests and analyses made in accordance with applicable ASTM standards, or reports from a recognized commercial laboratory, including chemical and tensile properties of each shipment of structural steel or part thereof having common properties.

1.05 QUALITY ASSURANCE

A. Welding:
   1. Perform welding of structural metals in accordance with AWS D1.6 using welders who have current AWS qualification certificate for the process, position, and joint configuration to be welded.
   2. Make Welding Procedure Specifications available at the locations where welding is performed.
   3. Notify Engineer at least 24 hours before starting shop or field welding.
   4. Engineer may check materials, equipment, and qualifications of welders.
   5. Remove welders performing unsatisfactory Work, or require requalification.
   6. Engineer may use gamma ray, magnetic particle, dye penetrant, trepanning, or other aids to visual inspection to examine any part of welds or all welds.
   7. Contractor shall bear costs of retests on defective welds.
   8. Contractor shall also bear costs in connection with qualifying welders.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Packing and shipping: Deliver structural steel free from mill scale, rust, and pitting.

B. Storage and protection: Until erection and painting, protect from weather items not galvanized or protected by a shop coat of paint.

PART 2 PRODUCTS

2.01 MATERIALS

A. Unless otherwise specified or indicated on the Drawings, materials shall conform to the following:
### Item | ASTM Standard | Class, Grade, Type, or Alloy Number
---|---|---
**Carbon Steel**
Plate, bars, rolled shapes (except W and WT shapes), and miscellaneous items | A36 | --
Rolled W and WT shapes | A992 | Grade 50
Hollow structural sections/HSS: Round, square, or rectangular (including “pipe” where indicated for structural members and supports) | A500 | Grade C

**Stainless steel**
Plate, sheet, and strip | A240 | Type 304\(^{(1)}\) or 316\(^{(2)}\)
Bars and shapes | A276 | Type 304\(^{(1)}\) or 316\(^{(2)}\)

Notes:
1. Use Type 304L (low-carbon stainless steel) if material will be welded.
2. Use Type 316L (low carbon stainless steel) if material will be welded.

### 2.02 FASTENERS AND STRUCTURAL HARDWARE

**A. General:**
2. Where fasteners and hardware are specified to be galvanized, hot-dip galvanize in accordance with ASTM A153 or ASTM F2329, unless otherwise specified.

**B. All thread rods:**
1. Carbon steel:
   a. In accordance with ASTM A36 unless otherwise indicated on the Drawings.
2. Galvanized carbon steel:
   a. In accordance with ASTM A36 unless otherwise indicated on the Drawings, and hot dip galvanized in accordance with ASTM A153.

**C. Anchor bolts, anchor rods, and post-installed steel anchors:** As indicated on the Drawings and as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
D. Stainless steel bolts (for use in stainless steel structures):
   1. General:
      a. Bolts and nuts shall be the products of a single manufacturer/fabricator to ensure proper fit without galling. Ship bolts with properly fitting nuts attached.
      b. Units descaled, pickled and passivated as specified in “Fabrication.”
   2. Alloy: Type 304 or Type 316 to match alloy of structural members being connected.
   3. Type 304:
      a. Bolts: ASTM F593, Group 1, Condition CW, coarse threads.
      c. Washers: Type 304 stainless steel.
   4. Type 316:
      a. Bolts: ASTM F593, Group 2, Condition CW, coarse threads.
      c. Washers: Type 316 stainless steel.

2.03 ISOLATING SLEEVES AND WASHERS

A. As indicated on the Drawings and as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.

2.04 SUPPLEMENTARY PARTS

A. Furnish as required for complete structural steel erection, whether or not such parts and Work are specified or indicated on the Drawings.

2.05 FABRICATION

A. Shop assembly:
   1. Fabricate structural steel in accordance with AISC 360 and AISC 303 unless otherwise specified or modified by applicable regulatory requirements.
   2. Where anchors, connections, or other details of structural steel are not specifically indicated on the Drawings or specified, their material, size and form shall be equivalent in quality and workmanship to items specified.
   3. Round off sharp and hazardous projections and grind smooth.
   4. Take measurements necessary to properly fit work in the field. Take responsibility for and be governed by the measurements and proper working out of all the details.
   5. Take responsibility for correct fitting of metalwork.
   6. Welded connections:
      a. Comply with AWS requirements for the metals to be welded.
      b. Weld only in accordance with approved Welding Procedure Specifications.
c. Keep Welding Procedure Specifications readily available for welders and inspectors during fabrication processes.

B. Galvanized carbon steel:
   1. Where galvanizing is required, hot-dip structural steel after fabrication in accordance with ASTM A123:
   2. Do not electro-galvanize or mechanically-galvanize unless specified or accepted by Engineer.
   3. Re-straighten galvanized items that bend or twist during galvanizing.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of conditions: Examine Work in place to verify that it is satisfactory to receive the Work of this Section. If unsatisfactory conditions exist, do not begin this Work until such conditions have been corrected.

3.02 ERECTION

A. General:
   1. Fabricate structural and foundry items to true dimensions without warp or twist.
   2. Form welded closures neatly, and grind off smooth where weld material interferes with fit or is unsightly.
   3. Install structural items accurately and securely, true to level, plumb, in correct alignment and grade, with all parts bearing or fitting structure or equipment for which intended.
   4. Do not shift out of alignment, re-drill, re-shape, or force fit fabricated items.
   5. Place anchor bolts or other anchoring devices accurately and make surfaces that bear against structural items smooth and level.
   6. Rigidly support and brace structural items needing special alignment to preserve straight, level, even, and smooth lines. Keep structural items braced until concrete, grout, or dry pack mortar has hardened for 48 hours minimum.
   7. Erect structural steel in accordance with AISC 303 unless otherwise specified or modified by applicable regulatory requirements.
   8. Where anchors, connections, and other details of structural steel erection are not specifically indicated on the Drawings or specified, form, locate, and attach with equivalent in quality and workmanship to items specified.
   9. Round off sharp or hazardous projections and grind smooth.
   10. Paint or coat steel items as specified in Section 09960 - High-Performance Coatings.

B. Welding: General:
   1. Make welds full penetration type, unless otherwise indicated on the Drawings.
2. Remove backing bars and weld tabs after completion of weld. Repair defective welds observed after removal of backing bars and weld tabs.

C. Welding: Carbon steel:
   1. General: In accordance with AWS D1.1:
      a. Weld ASTM A36 and A992 structural steel, and ASTM A500 and A501 structural tubing with electrodes in accordance with AWS A5.1, using E70XX electrodes; AWS A5.17, using F7X-EXXX electrodes; or AWS A5.20, using E7XT-X electrodes:

D. Interface with other products:
   1. Where steel members and fasteners come in contact with dissimilar metals (aluminum, stainless steel, etc.), separate or isolate the dissimilar metals with isolating sleeves and washers as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.

E. Fasteners: General:
   1. Install bolts to project 2 threads minimum, but 1/2 inch maximum beyond nut.
   2. Anchor bolts and anchor rods: Install as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
      a. Unless otherwise specified, tighten nuts on anchor bolts and anchor rods specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry to the "snug-tight" condition.
   3. All thread rods in drilled holes bonded to concrete with adhesive: Install as specified in Section 03055 - Adhesive-Bonded Reinforcing Bars and All Thread Rods in Concrete.

F. Fasteners: High-strength carbon steel bolts:
   1. Connections with high-strength bolts shall in accordance with RCSC Specification for Structural Joints Using High-Strength Bolts.
      a. Confirm that faying surfaces at connections are free of dirt and other foreign material, have been blast cleaned, and are free of coatings and inadvertent overspray in accordance with RCSC Specification.
      b. Furnish hardened flat washers in accordance with ASTM F436:
         1) On outer plies with slotted holes.
         2) When 1 or more plies of the connected material has a yield strength less than 40 ksi.
         3) Under element, nut, or bolt head, turned in tightening.
      c. Install tension indicator washers, placed in accordance with ASTM F959 Figure X1, to confirm adequate tightening of bolts.
      d. Tighten bolts to full pretension.
3.03 FIELD QUALITY CONTROL

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

3.04 FIELD QUALITY ASSURANCE

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

B. Special inspections, special tests, and structural observation:
   1. Provide as specified in Section 01455B - Special Tests and Inspections.

END OF SECTION
PART 1   GENERAL

1.01 SUMMARY

   A. Section includes: Structural aluminum products, including sheet, pipe, extrusions, and associated accessories.

1.02 REFERENCES

   A. ASTM International (ASTM):

   B. American Welding Society (AWS):
      1. A5.10 - Specification for Bare Aluminum and Aluminum-Alloy Welding Electrodes and Rods.
      2. D1.2 - Structural Welding Code - Aluminum.

1.03 SUBMITTALS

   A. Quality control submittals:
      1. Test Reports: Certified copies of mill tests or reports from a recognized commercial laboratory including chemical and tensile properties of each shipment of structural metal or part thereof having common properties. Tests and analyses shall be made in accordance with applicable ASTM Standards.
      2. Welder’s certificates.

1.04 QUALITY ASSURANCE

   A. Qualifications:
      1. Perform welding of structural metals with welders who have current AWS certificate for the type of welding to be performed.
      2. Notify Engineer 24 hours minimum before starting shop or field welding.
      3. Engineer may check materials, equipment, and qualifications of welders.
      4. Remove welders performing unsatisfactory work, or require to requalify.
      5. Engineer may use gamma ray, magnetic particle dye penetrant, or other aids to visual inspection to examine any part of welds or all welds.
6. Contractor shall bear costs of retests on defective welds.
7. Contractor shall bear costs in connection with qualifying welders.

PART 2  PRODUCTS

2.01  MATERIALS

C. Extruded aluminum: ASTM B221, Alloy 6063-T42.
D. Isolating sleeves and washers:
   1. As indicated on the Drawings and as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
E. Miscellaneous materials:
   1. Furnish supplementary parts necessary to complete each item even where such work is neither definitely indicated on the Drawings nor specified.
   2. Size, form, attachment, and location shall conform to the best of current practice.
   3. Conform to applicable ASTM Standards for materials not otherwise specified.

2.02  FABRICATION

A. Aluminum layout:
   1. Center punch hole centers, and punch or scribe cutoff lines, except where marks would remain on fabricated material.
   2. Apply temperature correction where necessary in layout of critical dimensions. Use a coefficient of expansion of 0.000013 per degree of Fahrenheit.
B. Cutting aluminum:
   1. Material 1/2-inch thick or less: Shear, saw, or cut with a router.
   2. Material more than 1/2-inch thick: Saw or rout.
   3. Make cut edges true and smooth, free from excessive burrs or ragged breaks.
   4. Avoid reentrant cuts wherever possible. Where used, fillet by drilling prior to cutting.
   5. Do not flame cut aluminum alloys.
   6. Punch or drill rivet or bolt holes to finished size before assembly:
      a. Make finished diameter of holes for bolts 1/16-inch maximum larger than nominal bolt diameter.
      b. Make holes cylindrical and perpendicular to principal surface.
      c. Do not permit holes to drift in a manner to distort metal.
C. Aluminum forming and assembly:
   1. Do not heat structural aluminum, except as follows:
      a. Heat aluminum to 400 degrees Fahrenheit for 30 minutes maximum, to facilitate bending or welding.
      b. Heat only when proper temperature controls and supervision can ensure that limitations on temperature and time are observed.

D. Before assembly, remove chips lodged between contacting surfaces.

E. Welding aluminum:
   1. Perform welding of aluminum in accordance with AWS D1.2.
   2. Weld aluminum in accordance with the following:
      a. Preparation:
         1) Remove dirt, grease, forming or machining lubricants, and organic materials from areas to be welded by cleaning with a suitable solvent or by vapor degreasing.
         2) Additionally, etch or scratch brush to remove oxide coating just prior to welding when inert gas tungsten arc welding method is used.
         3) Oxide coating may not need to be removed if welding is performed by automatic or semi-automatic inert gas shielded metal arc.
         4) Suitably prepare edges to ensure 100 percent penetration in butt welds by sawing, chipping, machining, or shearing. Do not cut with oxygen.
      b. Filler metal: Aluminum alloys conforming to the requirements of AWS A5.10 and AWS classification ER 4043, ER 5654, ER 5554, ER 5183, ER 5356, or ER 5556.
      c. Perform welding of structures which are to be anodized using filler alloys which will not discolor when anodized, AWS ER 5654, ER 5554, ER 5183, ER 5356, or ER 5556.
      d. Perform welding by using a non-consumable tungsten electrode with filler metal in an inert gas atmosphere (TIG) or using a consumable filler metal electrode in an inert gas atmosphere (MIG).
      e. Do not use welding process that requires use of a welding flux.
      f. Neatly make welded closures.
      g. Where weld material interferes with fit or is unsightly in appearance, grind it smooth.
      h. Make welds full penetration welds unless otherwise indicated on the Drawings.
PART 3    EXECUTION

3.01    EXAMINATION

A. Verification of conditions: Examine Work in place to verify that it is satisfactory to receive the Work of this Section. If unsatisfactory conditions exist, do not begin this Work until such conditions have been corrected.

3.02    INSTALLATION

A. Install structural aluminum products as indicated on the Drawings and specified.

B. Install structural aluminum products accurately and securely, true to level, plumb, in correct alignment and grade, with all parts bearing or fitting structure or equipment for which intended.

C. Do not cock out of alignment, redrill, reshape, or force fit fabricated items.

D. Place anchor bolts or other anchoring devices accurately and make surfaces that bear against structural items smooth and true to level.

E. Rigidly support and brace structural products needing special alignment to preserve straight, level, even, smooth lines, and keep braced until concrete, grout, or dry pack mortar has hardened for a minimum 48-hour period.

F. Interface with other products:
   1. Where aluminum comes in contact with dissimilar metals, use stainless steel bolts or anchors and separate or isolate the dissimilar metals with isolating sleeves and washers as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
   2. Coat those parts of aluminum that will be cast into concrete or that will be in contact with concrete, grout, masonry, wood, or other materials that will cause the aluminum to corrode, as specified in Section 09960 - High-Performance Coatings.

END OF SECTION
SECTION 05190
MECHANICAL ANCHORING AND FASTENING TO CONCRETE AND MASONRY

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Cast-in anchors and fasteners:
      a. Anchor bolts.
      b. Anchor rods.
      c. Concrete inserts.
   2. Post-installed steel anchors and fasteners:
      a. Concrete anchors.
   3. Appurtenances for anchoring and fastening:
      a. Anchor bolt sleeves.
      b. Isolating sleeves and washers.
      c. Thread coating for threaded stainless steel fasteners.

1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. 355.2 - Qualification of Post-Installed Mechanical Anchors in Concrete & Commentary.

B. American National Standards Institute (ANSI):

C. American Welding Society (AWS):
   1. D1.1 - Structural Welding Code - Steel.
   2. D1.6 - Structural Welding Code - Stainless Steel.

D. ASTM International (ASTM):

1.03 DEFINITIONS

A. Built-in anchor: Headed bolt or assembly installed in position before filling surrounding masonry units with grout.

B. Cast-in anchor: Headed bolt or assembly installed in position before placing plastic concrete around.

C. Overhead installations: Fasteners installed on overhead surfaces where the longitudinal axis of the fastener is more than 60 degrees above a horizontal line so that the fastener resists sustained tension loads.

D. Passivation: Chemical treatment of stainless steel with a mild oxidant for the purpose of enhancing the spontaneous formation of the steel’s protective passive film.

E. Post-installed anchor: Fastener or assembly installed in hardened concrete or finished masonry construction, typically by drilling into the structure and inserting a steel anchor assembly.
F. Terms relating to structures or building environments as used with reference to anchors and fasteners:
   1. Corrosive locations: Describes interior and exterior locations as follows:
      a. Locations used for delivery, storage, transfer, or containment (including spill containment) of chemicals used for plant treatment processes.
   2. Wet and moist locations: Describes locations, other than “corrosive locations,” that are submerged, are immediately above liquid containment structures, or are subject to frequent wetting, splashing, or wash down. Includes:
      a. Exterior portions of buildings and structures.
      b. Liquid-containing structures:
         1) Locations at and below the maximum operating liquid surface elevation.
         2) Locations above the maximum operating liquid surface elevation and:
            a) Below the top of the walls containing the liquid.
            b) At the inside faces and underside surfaces of a structure enclosing or spanning over the liquid (including walls, roofs, slabs, beams, or walkways enclosing the open top of the structure).
      c. Liquid handling equipment:
         1) Bases of pumps and other equipment that handles liquids.
      d. Indoor locations exposed to moisture, splashing, or routine wash down during normal operations, including floors with slopes toward drains or gutters.
      e. Other locations indicated on the Drawings.
   3. Other locations:
      a. Interior dry areas where the surfaces are not exposed to moisture or humidity in excess of typical local environmental conditions.

1.04 SUBMITTALS

A. General:
   1. Submit as specified in General Conditions.
   2. Submit information listed for each type of anchor or fastener to be used.

B. Action submittals:
   1. Product data:
      a. Cast-in anchors:
         1) Manufacturer’s data including catalog cuts showing anchor sizes and configuration, materials, and finishes.
      b. Post-installed anchors:
         1) For each anchor type, manufacturer’s data including catalog cuts showing anchor sizes and construction, materials and finishes, and load ratings.
2. Samples:
   a. Samples of each type of anchor, including representative diameters and lengths, if requested by the Engineer.

3. Certificates:
   a. Cast-in anchors:
      1) Mill certificates for steel anchors that will be supplied to the site.
   b. Post-installed anchors:
      1) Manufacturer’s statement or certified test reports demonstrating that anchors that will be supplied to the site comply with the materials properties specified.

4. Test reports:
   a. Post-installed anchors: For each anchor type used for the Work:
      1) Current ICC-ES Report (ESR), or equivalent acceptable to the Engineer and the authority having jurisdiction, demonstrating:
         a) Acceptance of that anchor for use under the building code specified in Section 01410 - Regulatory Requirements.
         b) That testing of the concrete anchor included the simulated seismic tension and shear tests of AC193, and that the anchor is accepted for use in Seismic Design Categories C, D, E, or F and with cracked concrete.

5. Manufacturer’s instructions:
   a. Requirements for storage and handling.
   b. Recommended installation procedures including details on drilling, hole size (diameter and depth), hole cleaning and preparation procedures, anchor insertion, and anchor tightening.
   c. Requirements for inspection or observation during installation.

6. Qualification statements:
   a. Post-installed anchors: Installer qualifications:
      1) Submit list of personnel performing installations and include date of manufacturer’s training for each.

1.05 QUALITY ASSURANCE

A. Qualifications:
   1. Post installed anchors shall be in accordance with building code specified in Section 01410 - Regulatory Requirements.
   2. Installers: Post-installed mechanical anchors:
      a. Installations shall be performed by trained installers having at least 3 years of experience performing similar installations with similar types of anchors.

B. Special inspection:
   1. Provide special inspection of post-installed anchors as specified in Section 01455B - Special Tests and Inspections and this Section.
1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver post-installed anchors in manufacturer’s standard packaging with labels visible and intact. Include manufacturer’s installation instructions.

B. Handle and store anchors and fasteners in accordance with manufacturer’s recommendations and as required to prevent damage.

C. Protect anchors from weather and moisture until installation.

1.07 PROJECT CONDITIONS

A. As specified in Section 01610 - Project Design Criteria.

B. Seismic Design Category (SDC) for structures is indicated on the Drawings.

PART 2 PRODUCTS

2.01 MANUFACTURED UNITS

A. General:
   1. Furnish threaded fasteners with flat washers and hex nuts fabricated from materials corresponding to the material used for threaded portion of the anchor.
      a. Cast-in anchors: Provide flat washers and nuts as listed in the ASTM standard for the anchor materials specified.
      b. Post-installed anchors: Provide flat washers and nuts supplied for that product by the manufacturer of each anchor.
   2. Size of anchors and fasteners, including diameter and length or minimum effective embedment depth: As indicated on the Drawings or as specified in this Section. In the event of conflicts, contact Engineer for clarification.
   3. Where anchors and connections are not specifically indicated on the Drawings or specified, their material, size and form shall be equivalent in quality and workmanship to items specified.

B. Materials:
   1. Provide and install anchors of materials as in this Section.

2.02 CAST-IN ANCHORS AND FASTENERS

A. Anchor bolts:
   1. Description:
      a. Straight steel rod having one end with an integrally forged head, and one threaded end. Embedded into concrete with the headed end cast into concrete at the effective embedment depth indicated on the Drawings or
specified, and with the threaded end left to project clear of concrete face as required for the connection to be made.

b. Furnish anchor bolts with heavy hex forged head or equivalent acceptable to Engineer.
   1) Rods or bars with angle bend for embedment in concrete (i.e., “L” or “J” shaped anchor bolts) are not permitted in the Work.

2. Materials:
   a. Ship anchor bolts with properly fitting nuts attached.
   b. Type 316 stainless steel:
      1) Surfaces descaled, pickled, and passivated in accordance with ASTM A380.
      2) Bolts: ASTM F593, Group 2, Condition CW, coarse threads.
      3) Nuts: ASTM F594. Match alloy (group and UNS designation) and threads of bolts.
      4) Washers: Type 316 stainless steel.
   c. Type 304 stainless steel:
      1) Surfaces descaled, pickled, and passivated in accordance with ASTM A380.
      2) Bolts: ASTM F593, Group 1, Condition CW, coarse threads.
      3) Nuts: ASTM F594. Match alloy (group and UNS designation) and threads of bolts.
      4) Washers: Type 304 stainless steel.
   d. Galvanized steel:
      1) Hot-dip galvanized coating in accordance with ASTM F2329.
      2) Bolt: ASTM F1554, Grade 36, heavy hex, coarse thread.
      3) Nuts: ASTM A563, Grade A, heavy hex, threads to match bolt.
      4) Washers: ASTM F436, Type 1.

B. Anchor rods:
   1. Description: Straight steel rod having threads on each end or continuously threaded from end to end. One threaded end is fitted with nuts or plates and embedded in concrete to the effective depth indicated on the Drawings, leaving the opposite threaded end to project clear of the concrete face as required for the connection to be made at that location.
   2. Materials:
      a. Stainless steel: Type 316:
         1) Surfaces descaled, pickled, and passivated in accordance with ASTM A380.
         2) Rod: ASTM F593, Group 2, Condition CW, coarse threads.
         3) Nuts: ASTM F594. Match alloy (group and UNS designation) and threads of rods.
         4) Washers: Type 316 stainless steel.
b. Stainless steel: Type 304:
   1) Surfaces descaled, pickled, and passivated in accordance with ASTM A380.
   2) Rod: ASTM F593, Group 1, Condition CW, coarse threads.
   3) Nuts: ASTM F594. Match alloy (group and UNS designation) and threads or rods.
   4) Washers: Type 304 stainless steel.

c. Galvanized: steel:
   1) Hot-dip galvanized with coating in accordance with ASTM F2329.
   2) Rod: ASTM F1554, Grade 36 coarse thread.
   3) Nuts: ASTM A563, Grade A, threads to match rod.
   4) Washers: ASTM F436, Type 1.

C. Concrete insert: Ductile embed:
   1. Description: 1-piece, integrally hot forged sleeve for embedment in concrete. Provided with flange for nailing to forms and female threaded coupler at the exposed concrete face, and washer-faced hex headed foot to resist pullout from concrete at the embedded end.
   2. Manufacturers: The following or equal:
      a. Dayton Superior, F-54 Ductile Embed Insert.
   3. Materials:
      a. Galvanized steel:
         1) Hot-dip galvanized coating in accordance with ASTM A123 or A153 where indicated on the Drawings.
         2) Steel: ASTM A29 hot rolled, Grade 1045.
   4. Materials:
      a. Stainless steel: Type 316L or as indicated on the Drawings.
      b. Galvanized steel:
         1) Hot-dip galvanized after fabrication with coating in accordance with ASTM A123.
         2) Steel: Carbon steel in accordance with ASTM A108 with 50,000 pounds per square inch minimum yield strength, and 60,000 pounds per square inch minimum tensile strength.

D. Steel plates or shapes for fabrications including assemblies with welded studs or deformed bar anchors:
   1. Stainless steel: Type 316L or Type 304L:
   2. Galvanized steel:
      a. Hot dip galvanized in accordance with ASTM A123.
      b. Steel: ASTM A36.
2.03 POST-INSTALLED ANCHORS AND FASTENERS - ADHESIVE

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

2.04 POST-INSTALLED ANCHORS AND FASTENERS - MECHANICAL

A. General:
   1. Post-installed anchors used for the Work shall hold a current ICC Evaluation Service Report demonstrating acceptance for use under the building code specified in Section 01410 - Regulatory Requirements:
      a. Conditions of use: The acceptance report shall indicate acceptance of the product for use under the following conditions:
         1) In regions of concrete where cracking has occurred or may occur.
         2) To resist short-term loads due to wind forces.
         3) To resist short-term loading due to seismic forces for the Seismic Design Category of the structure where the product will be used.
   2. Substitutions: When requesting product substitutions, submit calculations, indicating the diameter, effective embedment depth and spacing of the proposed anchors, and demonstrating that the substituted product will provide load resistance that is equal to or greater than that provided by the anchors listed in this Section.
      a. Calculations shall be prepared by and shall bear the signature and seal of a Civil or Structural Engineer licensed in the State of California.
      b. Decisions regarding the acceptability of proposed substitutions shall be at the discretion of the Engineer.

B. Concrete anchors:
   1. Description. Post-installed anchor assembly consisting of a threaded stud and a surrounding wedge expansion sleeve that is forced outward by torquing the center stud to transfer loads from the stud to the concrete through bearing, friction, or both. (Sometimes referred to as “expansion anchors” or “wedge anchors.”)
      a. Do not use slug-in, lead cinch, and similar systems relying on deformation of lead alloy or similar materials to develop holding power.
   2. Concrete anchors for anchorage to concrete:
      a. Acceptance criteria:
         1) Concrete anchors shall have a current ICC-ES Report demonstrating that the anchors have been tested and qualified for performance in both cracked and un-cracked concrete, and for short-term loading due to wind and seismic forces for Seismic Design Categories A through F in accordance with ACI 355.2 and with ICC-ES AC193 (including all mandatory tests and optional tests for seismic tension and shear in cracked concrete).
2) Concrete anchor performance in the current ICC-ES Report shall be “Category 1” as defined in ACI 355.2.

b. Manufacturers: One of the following or equal:
   1) Hilti, Kwik Bolt TZ Expansion Anchor.
   2) DEWALT/Powers, PowerStud+ SD2.
   3) Simpson Strong-Tie, Strong Bolt 2 Wedge Anchor.

c. Materials. Integrimly threaded stud, wedge, washer, and nut:
   1) Stainless steel: Type 316.
   2) Galvanized: Carbon steel, zinc plated in accordance with ASTM B633, minimum 5 microns (Fe/Zn 5).

C. Flush shells:
   1. Description: Post-installed anchor assembly consisting of an internally threaded mandrel that is forced into a pre-drilled concrete hole with a setting tool until the top of the anchor is flush with the face of the concrete. Once installed, a removable threaded bolt is installed in the mandrel.

2. Flush shell anchors are not permitted in the Work.

D. Undercut concrete anchors:
   1. Description: Post-installed concrete anchor that develops tensile strength from mechanical interlock provided by creation of an undercut “key” at the embedded end of the anchor. The undercut may be achieved with a special drill before anchor installation, or by the anchor itself during installation.

2. Acceptance criteria:
   a. Acceptance criteria:
      1) Undercut concrete anchors shall have a current ICC-ES Report demonstrating that the anchors have been tested and qualified for performance in both cracked and un-cracked concrete, and for short-term loading due to wind and seismic forces for Seismic Design Categories A through F in accordance with ACI 355.2 and ICC ES AC193 (including all mandatory tests and optional tests for seismic tension and shear in cracked concrete).

      2) Undercut anchor performance in the current ICC-ES Report shall be “Category 1” as defined in ACI 355.2.

   b. Use pre-setting units. Through-setting units are not allowed unless prior written acceptance for specific locations is obtained from the Engineer.

3. Manufacturers: One of the following or equal:
   a. Hilti, HDA (carbon steel) or HDA-R (stainless steel) Undercut Anchor.
   c. Simpson Strong-Tie, Torq-Cut Anchor.
   d. USP Structural Connectors, DUC-L Undercut Anchors.

4. Materials:
   a. Stainless steel: Corrosive, wet, and moist locations: Type 316.
   b. Galvanized: Carbon steel, zinc plated in accordance with ASTM B633, minimum 5 microns (Fe/Zn 5).
2.05 APPURTEANCES FOR ANCHORING AND FASTENING

A. Anchor bolt sleeves:
   1. Having inside diameter approximately 2 inches greater than bolt diameter and minimum 10-bolt diameters long.
   2. Plastic sleeves:
      a. High-density polyethylene, corrugated sleeve, threaded to provide adjustment of location on the anchor bolt.
      b. Manufacturers: The following or equal:
         1) Portland Bolt & Manufacturing Co.
   3. Fabricated steel sleeves:
      a. Fabricate to the following dimensions unless otherwise indicated on the Drawings:
         1) Inside diameter: At least 2 inches greater than bolt diameter.
         2) Inside length: Not less than 10 bolt diameters.
         3) Bottom plate:
            a) Square plate with dimensions equal to the outside diameter of the sleeve plus 1/2 inch each side.
            b) Thickness equal to or greater than one-half of the anchor bolt diameter.
      b. Carbon steel anchor bolts:
         1) Fabricated from ASTM A36 plate and ASTM A53, Grade B pipe.
         2) Welded connections: Conform to requirements of AWS D1.1.
         3) Hot dip galvanized in accordance with ASTM A153.
      c. Stainless steel anchor bolts:
         1) Fabricated from ASTM A240 plate and pipe. Type 304L or Type 316L to match Type of the anchor bolt.
         2) Welded connections: In accordance with AWS D1.6.

B. Isolating sleeves and washers:
   1. Manufacturers: One of the following or equal:
      a. Central Plastics Co.
      b. Allied Corrosion Industries.
   2. Sleeves: Mylar, 1/32-inch thick, 4,000 volts per mil dielectric strength, of proper size to fit bolts and extending half way into both steel washers.
   3. One sleeve required for each bolt.
   4. Washers: The inside diameter of all washers shall fit over the isolating sleeve, and both the steel and isolating washers shall have the same inside diameter and outside diameter.
      a. Proper size to fit bolts.
      b. Two 1/8-inch thick steel washers for each bolt.
      c. G3 Phenolic: 2 insulating washers are required for each bolt:
         1) Thickness: 1/8 inch.
         2) Base material: Glass.
         3) Resin: Phenolic.
4) Water absorption: 2 percent.
5) Hardness (Rockwell): 100.
6) Dielectric strength: 450 volts per mil.
7) Compression strength: 50,000 pounds per square inch.
8) Tensile strength: 20,000 pounds per square inch.
9) Maximum operating temperature: 350 degrees Fahrenheit.

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

D. Thread coating: For use with threaded stainless steel fasteners:
   1. Manufacturers: One of the following or equal:
      b. Oil Research, Inc., WLR No. 111.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine Work in place to verify that it is satisfactory to receive the Work of this Section. If unsatisfactory conditions exist, do not begin this Work until such conditions have been corrected.

3.02 INSTALLATION: GENERAL

A. Where anchors and fasteners are not specifically indicated on the Drawings or specified, make attachments with materials specified in this Section.

B. Substitution of anchor types:
   1. Post-installed anchors may not be used as an alternative to cast-in/built-in anchors at locations where the latter are indicated on the Drawings.
   2. Cast-in/built-in anchors may be used as an alternative to post-installed mechanical anchors at locations where the latter are indicated on the Drawings.

C. Protect products from damage during installation. Take special care to protect threads and threaded ends.

D. Accurately locate and position anchors and fasteners:
   1. Unless otherwise indicated on the Drawings, install anchors perpendicular to the surfaces from which they project.
   2. Install anchors so that at least 2 threads, but not more than 1/2 inch of threaded rod, projects past the top nut.
E. Interface with other products:
   1. Where steel anchors come in contact with dissimilar metals (aluminum, stainless steel, etc.), use stainless steel anchors and separate or isolate dissimilar metals using isolating sleeves and washers.
   2. Prior to installing nuts, coat threads of stainless steel fasteners with thread coating to prevent galling of threads.

3.03 INSTALLATION: CAST-IN ANCHORS

A. General:
   1. Accurately locate cast-in and built-in anchors.
      a. Provide anchor setting templates to locate anchor bolts and anchor rods. Secure templates to formwork.
      b. Brace or tie off embedments as necessary to prevent displacement during placement of plastic concrete or of surrounding masonry construction.
      c. Position and tie cast-in and built-in anchors in place before beginning placement of concrete or grout. Do not “stab” anchors into plastic concrete, mortar, or grout.
      d. Do not allow cast-in anchors to touch reinforcing steel. Where cast-in anchors are within 1/4 inch of reinforcing steel, isolate the metals by wrapping the anchors with a minimum of 4 wraps of 10-mil polyvinyl chloride tape in area adjacent to reinforcing steel.
   2. For anchoring at machinery bases subject to vibration, use 2 nuts, with 1 serving as a locknut.
   3. Where anchor bolts or anchor rods are indicated on the Drawings as being for future use, thoroughly coat exposed surfaces that project from concrete or masonry with non-oxidizing wax. Turn nuts down full length of the threads, and neatly wrap the exposed thread and nut with a minimum of 4 wraps of 10-mil waterproof polyvinyl tape.

B. Anchor bolts:
   1. Minimum effective embedment: 10-bolt diameters, unless a longer embedment is indicated on the Drawings.
   2. Where indicated on the Drawings, set anchor bolts in plastic, galvanized steel or stainless steel sleeves to allow for adjustment. Seal top of sleeve to prevent grout from filling sleeve. Fill sleeves with grout when a machine or other equipment is grouted in place.

C. Anchor rods:
   1. Install as specified for anchor bolts.

D. Concrete inserts:
   1. Provide inserts with minimum clear concrete cover not less than that specified for reinforcing bars.
E. Welded studs:
   1. Butt weld to steel fabrications with automatic stud welding gun as recommended by the manufacturer.
   2. Ensure that butt weld develops full strength of the stud.

3.04 INSTALLATION: POST-INSTALLED ADHESIVE ANCHORS

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

3.05 INSTALLATION: POST-INSTALLED MECHANICAL ANCHORS

A. General:
   1. Install anchors in accordance with the manufacturer’s instructions, ACI 355.2, the anchor’s ICC-ES Report. Where conflict exists between the ICC-ES Report and the requirements in this Section, the requirements of the ICC-ES Report shall control.
   2. Where anchor manufacturer recommends the use of special tools and/or specific drill bits for installation, provide and use such tools.
   3. After anchors have been positioned and inserted into concrete or masonry, do not:
      a. Remove and reuse/reinstall anchors.
      b. Loosen or remove bolts or studs.

B. Holes drilled into concrete and masonry:
   1. Do not drill holes in concrete or masonry until the material has achieved its minimum specified compression strength (f’c or f’m).
   2. Accurately locate holes:
      a. Before drilling holes, use a reinforcing bar locator to identify the position of all reinforcing steel, conduit, and other embedded items within a 6-inch radius of each proposed hole.
      b. If the hole depth exceeds the range of detection for the rebar locator, the Engineer may require radiographs of the area designated for investigation before drilling commences.
   3. Exercise care to avoid damaging existing reinforcement and other items embedded in concrete and masonry.
      a. If embedments are encountered during drilling, immediately stop work and notify the Engineer. Await Engineer’s instructions before proceeding.
   4. Unless otherwise indicated on the Drawings, drill holes perpendicular to the concrete surface into which they are placed.
   5. Drill using anchor manufacturer’s recommended equipment and procedures:
      a. Unless otherwise recommended by the manufacturer, drill in accordance with the following:
         1) Drilling equipment: Electric or pneumatic rotary type with light or medium impact. Where edge distances are less than 2 inches, use
lighter impact equipment to prevent micro-cracking and concrete spalling during drilling process.

2) Drill bits: Carbide-tipped in accordance with ANSI B212-15. Hollow drills with flushing air systems are preferred.

6. Drill holes at manufacturer’s recommended diameter and to depth required to provide the effective embedment indicated.
7. Clean and prepare holes as recommended by the manufacturer and as required by the ICC-ES Report for that anchor.
   a. Unless otherwise recommended by anchor manufacturer, remove dust and debris using brushes and clean compressed air.
   b. Repeat cleaning process as required by the manufacturer’s installation instructions.
   c. When cleaning holes for stainless steel anchors, use only stainless steel or non-metallic brushes.

C. Insert and tighten (or torque) anchors in full compliance with the manufacturer’s installation instructions.
   1. Once anchor is tightened (torque), do not attempt to loosen or remove its bolt or stud.

D. Concrete anchors: Minimum effective embedment lengths unless otherwise indicated on the Drawings:

<table>
<thead>
<tr>
<th>Nominal Diameter</th>
<th>Minimum Effective Embedment Length In Concrete</th>
<th>Minimum Effective Embedment Length In Grouted Masonry</th>
<th>Minimum Member Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8 inch</td>
<td>2 1/2 inch</td>
<td>2 5/8 inch</td>
<td>8 inch</td>
</tr>
<tr>
<td>1/2 inch</td>
<td>3 1/2 inch</td>
<td>3 1/2 inch</td>
<td>8 inch</td>
</tr>
<tr>
<td>5/8 inch</td>
<td>4 1/2 inch</td>
<td>4 1/2 inch</td>
<td>10 inch</td>
</tr>
<tr>
<td>3/4 inch</td>
<td>5 inch</td>
<td>5 1/4 inch</td>
<td>12 inch</td>
</tr>
</tbody>
</table>

E. Flush shell anchors:
   1. Flush shell anchors are not permitted in the Work.
   2. If equipment manufacturer’s installation instructions recommend the use of flush shell anchors, contact Engineer for instructions before proceeding.

3.06 FIELD QUALITY CONTROL

A. Contractor shall provide quality control over the Work of this Section as specified in Section 01450 - Quality Control.
   1. Expenses associated with work described by the following paragraphs shall be paid by the Contractor.
B. Post-installed anchors:
   1. Review anchor manufacturer’s installation instructions and requirements of
      the Evaluation Service Report (hereafter referred to as “installation
documents”) for each anchor type and material.
   2. Observe hole-drilling and cleaning operations for conformance with the
      installation documents.
   3. Certify in writing to the Engineer that the depth and location of anchor holes,
      and the torque applied for setting the anchors conforms to the requirements
      of the installation documents.

3.07 FIELD QUALITY ASSURANCE

A. District will provide on-site observation and field quality assurance for the Work of
   this Section.
   1. Expenses associated with work described by the following paragraphs shall be
      paid by the District.

B. Field inspections and special inspections:
   1. Required inspections: Observe construction for conformance to the approved
      Contract Documents, the accepted submittals, and manufacturer’s installation
      instructions for the products used.
   2. Record of inspections:
      a. Maintain record of each inspection.
      b. Submit copies to Engineer upon request.
   3. Statement of special inspections: At the end of the project, prepare and
      submit to the Engineer and the authority having jurisdiction inspector’s
      statement that the Work was constructed in general conformance with the
      approved Contract Documents, and that deficiencies observed during
      construction were resolved.

C. Special inspections: Anchors cast into concrete and built into masonry.
   1. Provide special inspection during positioning of anchors and placement of
      concrete or masonry (including mortar and grout) around the following
      anchors:
      a. Anchor bolts.
      b. Anchor rods.
      c. Concrete inserts (all types).
   2. During placement, provide continuous special inspection at each anchor
      location to verify that the following elements of the installation conform to
      the requirements of the Contract Documents.
      a. Anchor:
         1) Type and dimensions.
         2) Material: Galvanized steel, Type 304 stainless steel, or Type 316
            stainless steel as specified in this Section or indicated on the
            Drawings.
3) Positioning: Spacing, edge distances, effective embedment, and projection beyond the surface of the construction.
4) Reinforcement at anchor: Presence, positioning, and size of additional reinforcement at anchors indicated on the Drawings.

3. Following hardening and curing of the concrete or masonry surrounding the anchors, provide periodic special inspection to observe and confirm the following:
   a. Base material (concrete or grouted masonry):
      1) Solid and dense concrete or grouted masonry material within required distances surrounding anchor.
      2) Material encapsulating embedment is dense and well-consolidated.

D. Special Inspections: Post-installed mechanical anchors placed in hardened concrete and in grouted masonry.
   1. Provide special inspection during installation of the following anchors:
      a. Concrete anchors.
   2. Unless otherwise noted, provide periodic special inspection during positioning, drilling, placing, and torquing of anchors.
      a. Provide continuous special inspection for post-installed anchors in “overhead installations” as defined in this Section.
   3. Requirements for periodic special inspection:
      a. Verify items listed in the following paragraphs for conformance to the requirements of the Contract Documents and the Evaluation Report for the anchor being used. Observe the initial installation of each type and size of anchor, and subsequent installation of the same anchor at intervals of not more than 4 hours.
         1) Any change in the anchors used, in the personnel performing the installation, or in procedures used to install a given type of anchor shall require a new “initial inspection.”
      b. Substrate: Concrete or masonry surfaces receiving the anchor are sound and of a condition that will develop the anchor’s rated strength.
      c. Anchor:
         1) Manufacturer, type, and dimensions (diameter and length).
         2) Material (galvanized, Type 304 stainless steel, or Type 316 stainless steel).
      d. Hole:
         1) Positioning: Spacing and edge distances.
         2) Drill bit type and diameter.
         3) Diameter, and depth.
         4) Hole cleaned in accordance with manufacturer’s required procedures. Confirm multiple repetitions of cleaning when recommended by the manufacturer.
         5) Anchor’s minimum effective embedment.
         6) Anchor tightening/installation torque.
4. Requirements for continuous special inspection:
a. The special inspector shall observe all aspects of anchor installation, except that holes may be drilled in his/her absence provided that he/she confirms the use of acceptable drill bits before drilling, and later confirms the diameter, depth, and cleaning of drilled holes.

E. Field tests:
1. District may, at any time, request testing to confirm that materials being delivered and installed conform to the requirements of the Specifications.
   a. If such additional testing shows that the materials do not conform to the specified requirements, the Contractor shall pay the costs of these tests.
   b. If such additional testing shows that the materials do conform to the specified requirements, the District shall pay the costs of these tests.

3.08 Non-conforming work

A. Remove misaligned or non-performing anchors.

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

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

3.09 SCHEDULES

A. Provide and install anchor materials as scheduled in the following Table.

<table>
<thead>
<tr>
<th>Table - Required Anchoring Materials by Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location/Exposure</td>
</tr>
<tr>
<td>-------------------</td>
</tr>
<tr>
<td><strong>1.</strong> Anchors into concrete and grouted masonry for attachment of carbon steel, including structural steel and other steel fabrications:</td>
</tr>
<tr>
<td>a) Interior dry areas</td>
</tr>
<tr>
<td>b) Locations with galvanized steel structures or fabrications</td>
</tr>
<tr>
<td>c) Exterior and interior wet and moist locations</td>
</tr>
<tr>
<td>d) Corrosive locations</td>
</tr>
</tbody>
</table>
### Table - Required Anchoring Materials by Location

<table>
<thead>
<tr>
<th>Location/Exposure</th>
<th>Materials</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2. Anchors into concrete and grouted masonry for attachment of aluminum, stainless steel, or fiber-reinforced plastic (FRP) shapes and fabrications:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Interior dry areas</td>
<td>Stainless steel - Type 304 or 316</td>
<td>1</td>
</tr>
<tr>
<td>b) Exterior and interior wet and moist locations</td>
<td>Stainless steel - Type 316</td>
<td>1</td>
</tr>
<tr>
<td>c) Corrosive locations</td>
<td>Stainless steel - Type 316</td>
<td>1</td>
</tr>
<tr>
<td><strong>3. Anchors for attaching equipment and its appurtenances:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) All locations</td>
<td>Stainless steel - Type 316 (unless Type 304 is specifically indicated in the specifications for the equipment.)</td>
<td>1</td>
</tr>
</tbody>
</table>

**Notes:**

(1) Where anchors are in contact with a metal that differs from that of the anchor, provide isolation sleeves and washers.

END OF SECTION
SECTION 05500
METAL FABRICATIONS

PART 1   GENERAL

1.01 SUMMARY

A. Section includes:
   1. Aluminum grating stair tread.
   2. Aluminum stair nosing.
   3. Cast iron stop plank grooves.
   4. Concrete inserts.
   5. Handrails and guardrails.
   7. Manhole frames and covers.
   8. Metal gratings.
   9. Metal tread plate.
  10. Preformed channel pipe supports.
   11. Stairs.
   12. Miscellaneous metals.
   13. Associated accessories to the above items.

1.02 REFERENCES

A. Aluminum Association (AA):
   1. DAF-45: Designations from Start to Finish.
      a. M12-C22-A41.

B. American Association of State Highway and Transportation Officials (AASHTO):

C. ASTM International (ASTM):
12. A500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
15. A653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.

D. American Welding Society (AWS):
   1. A2.4 - Standard Symbols for Welding, Brazing, and Nondestructive Examination.

E. Occupational Safety and Health Administration (OSHA).

1.03 DEFINITIONS

A. Passivation: Removal of exogenous iron or iron compounds from the surface of a stainless steel by means of chemical dissolution resulting from treatment with an acid solution that removes the surface contamination but does not significantly affect the stainless steel itself.

1.04 SUBMITTALS

A. Product Data:
   1. Aluminum grating stair tread.
   2. Aluminum stair nosing.
3. Cast iron stop plank grooves.
4. Handrails and guardrails.
5. Manhole frames and covers.
6. Metal grating.

B. Shop drawings:
   1. Handrails and guardrails:
      a. Including details on connection attachments, gates, kick plates, ladders, and angles.
      b. Indicate profiles, sizes, connection attachments, reinforcing, anchorage, size and type of fasteners, and accessories.
      c. Include erection drawings, elevations, and details where applicable.
      d. Indicate welded connections using standard AWS A2.4 welding symbols. Indicate net weld lengths.
   2. Ladders.
   3. Metal grating.
   4. Metal tread plate.
   5. Stairs.
   6. Miscellaneous metals.

C. Samples:
   1. Guardrails with specified finishes.

D. Quality control submittals:
   1. Design data.
   2. Test reports:
      a. Guardrails: 3 copies of certified tests performed by an independent testing laboratory certifying that guardrails meet current State and OSHA strength requirements.
      b. Gratings:
         1) Grating manufacturers' calculations showing that gratings will meet specified design load, stress, and deflection requirements for each size grating for each span.
         2) Reports of tests performed.

PART 2 PRODUCTS

2.01 MATERIALS

A. General: Unless otherwise specified or indicated on the Drawings, structural and miscellaneous metals in accordance with the standards of the ASTM, including the following:
<table>
<thead>
<tr>
<th>Item</th>
<th>ASTM Standard No.</th>
<th>Class, Grade Type or Alloy No.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cast Iron</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cast Iron</td>
<td>A48</td>
<td>Class 40B</td>
</tr>
<tr>
<td><strong>Steel</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Galvanized sheet iron or steel</td>
<td>A653</td>
<td>Coating G90</td>
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<tr>
<td>Coil (plate)</td>
<td>A635</td>
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<tr>
<td>Structural plate, bars, rolled shapes, and miscellaneous items (except W shapes)</td>
<td>A36</td>
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<tr>
<td>Rolled W shapes</td>
<td>A992</td>
<td>Grade 50</td>
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<tr>
<td>Standard bolts, nuts, and washers</td>
<td>A307</td>
<td>--</td>
</tr>
<tr>
<td>High strength bolts, nuts, and hardened flat washers</td>
<td>A325, A490</td>
<td>--</td>
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<td>Eyebolts</td>
<td>A489</td>
<td>Type 1</td>
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<tr>
<td>Tubing, cold-formed</td>
<td>A500</td>
<td>--</td>
</tr>
<tr>
<td>Tubing, hot-formed</td>
<td>A501</td>
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<td>Grade B</td>
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<td>Plate, sheet, and strip</td>
<td>A240</td>
<td>Type 304^{(1)} or 316^{(2)}</td>
</tr>
<tr>
<td>Bars and shapes</td>
<td>A276</td>
<td>Type 304^{(1)} or 316^{(2)}</td>
</tr>
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<td>Group 1 Condition CW</td>
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<td>Bolts (Type 316)</td>
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<td>Flashing sheet aluminum</td>
<td>B209</td>
<td>Alloy 5005-H14, 0.032 inches minimum thickness</td>
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<td>Alloy 6061-T6</td>
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</tr>
<tr>
<td>Extruded aluminum</td>
<td>B221</td>
<td>Alloy 6063-T42</td>
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**Notes:**
(1) Use Type 304L if material will be welded.
(2) Use Type 316L if material will be welded.

2. Stainless steels are designated by type or series defined by ASTM.
3. Where stainless steel is welded, use low-carbon stainless steel.
2.02 MANUFACTURED UNITS

A. Aluminum grating stair tread:
1. Manufacturers: One of the following or equal:
   a. Harsco Industrial IKG, Aluminum Grating Stair Tread with Mebac® nosing.
3. Size:
   a. Tread width: To equal tread spacing plus 1 inch minimum.
   b. Tread length: Length to suit stringer-to-stringer dimension on the Drawings.
4. Bolts: Type 316 stainless steel.

B. Aluminum stair nosing:
1. Manufacturers: One of the following or equal:
   a. Wooster Products, Inc., Type 101 Nosing.
3. For installation in cast-in-place stairs.
4. Configuration: 4 inches wide, fabricated with integrally cast stainless steel anchors at approximately 12-inch centers. Length to extend within 3 inches of stair edge on each side.

C. Cast iron stop plank grooves:
1. Manufacturers: One of the following or equal:
   a. Neenah Foundry Co., R-7500 Series, Type A.
   b. McKinley Iron Works, Type L.
2. Size: 2-inch wide groove opening by 1-1/2 inch deep, unless otherwise indicated on the Drawings.
3. Recess groove with the cast iron surface of the groove set flush with the concrete surface.

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

E. Handrails and guardrails:
1. General:
   a. Design and fabricate assemblies to conform to current local, State, and OSHA standards and requirements.
   b. Coordinate layout of assemblies and post spacings to avoid conflicts with equipment and equipment operators:
      1) Indicate on the shop drawings locations of such equipment.
2) Highlight locations where railings cannot be made continuous, and obtain Engineer’s directions on how to proceed before fabricating or installing railings.

2. Aluminum handrails and guardrails (nonwelded pipe):
   a. Rails, posts, and fitting-assembly spacers:
      1) In accordance with ASTM B429, 6005, 6063 or 6105, minimum Schedule 40, extruded aluminum pipe of minimum 1.89-inch outside diameter and 0.14-inch wall thickness.
   b. Kick plates: 6061 or 6105 aluminum alloy.
   c. Fastenings and fasteners: As recommended or furnished by the manufacturer.
   d. Other parts: 6063 extruded aluminum, or F214 or F514.0 aluminum castings:
      1) Fabrications: In accordance with ASTM B209 or ASTM B221 extruded bars:
         a) Bases: 6061 or 6063 extruded aluminum alloy.
      2) Plug screws or blind rivets: Type 305 stainless steel.
         a) Other parts: Type 300 series stainless steel.
   e. Finish of aluminum components:
      1) Anodized finish, 0.7 mil thick, applied to exposed surfaces after cutting. Aluminum Association Specification M12-C22-A41, mechanical finish non specular as fabricated, chemical finish-medium matte, anodic coating-clear Class I Architectural.
      2) Pretreat aluminum for cleaning and removing markings before anodizing.
   f. Fabrication and assembly:
      1) Fabricate posts in single, unspliced pipe length.
      2) Perform without welding.
      3) Do not epoxy bond the parts.
      4) Maximum clear opening between assembled railing components as indicated on the Drawings.
   g. Manufacturers: One of the following or equal:
      1) Moultrie Manufacturing Co., Wesrail.
      2) Golden Railings, Riveted System.
      3) Craneveyor Corp. Enerco Metals, C-V Rail.

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

F. Ladders:
   1. General:
      a. Type: Safety type conforming to local, State, and OSHA standards as minimum. Furnish guards for ladder wells.
      b. Size: 18 inches wide between side rails of length, size, shape, detail, and location indicated on the Drawings.
   2. Aluminum ladders:
      b. Rungs:
         1) 1-inch minimum solid square bar with 1/8-inch grooves in top and deeply serrated on all sides.
         2) Capable of withstanding 1,000 pound load without failure.
      c. Side rails: Minimum 4-inch by 1/2-inch flat bars.
      d. Finish of aluminum components:
         1) Anodized finish, 0.7 mil thick, applied to exposed surfaces after cutting. Aluminum Association Specification M12-C22-A41, mechanical finish non specular as fabricated, chemical finish-medium matte, anodic coating-clear Class I Architectural.
         2) Pretreat aluminum for cleaning and removing markings before anodizing.
      e. Fabrication:
         1) Welded construction, of size, shape, location, and details indicated on the Drawings.
         2) For ladders over 20 feet high, furnish standard ladder cages or fall prevention system designed in accordance with State and OSHA requirements.
      f. Fall prevention system: Include but not limit to railing, brackets, clamps, 2 sleeves, and 2 belts, satisfying OSHA safe climbing requirements:
         1) Manufacturers: One of the following or equal:
            b) Swager Communications, Climbers Buddy System.
   G. Manhole frames and covers:
      1. Material: Gray iron castings, in accordance with ASTM A48, Class 30-B.
      2. Type: Heavy-duty traffic type, with combined minimum set weight of 265 pounds.
      3. Machine horizontal and vertical bearing surfaces to fit neatly, with easily removable cover bearing firmly in frame without rocking.
      4. Frame:
         a. Bottom flange type.
         b. Approximately 4-1/2 inches frame height.
c. Dimensions as indicated on the Drawings.
   1) Minimum inside clear dimension may not be smaller than nominal diameter minus 2 inches.

5. Cover:
   a. Skid-resistant grid pattern design stamped with name of utility service provided by manhole, such as "ELECTRICAL," "SEWER," "TELEPHONE," or "WATER."
   b. Solid type without ventilation holes.


H. Metal gratings:
   1. General:
      a. Fabricate grating to cover areas indicated on the Drawings.
      b. Unless otherwise indicated on the Drawings, grating over an opening shall cover entire opening.
      c. Make cutouts in grating where required for equipment access or protrusion, including valve operators or stems, and gate frames.
      d. Band ends of grating and edges of cutouts in grating:
         1) End banding: 1/4 inch less than height of grating, with top of grating and top edge of banding flush.
         2) Cutout banding: Full-height of grating.
         3) Use banding of same material as grating.
         4) Panel layout: Enable installation and subsequent removal of grating around protrusions or piping.
         5) Openings 6 inches and larger: Lay out grating panels with edges of 2 adjacent panels located on centerline of opening.
         6) Openings smaller than 6 inches: Locate opening at edge of single panel.
         7) Where an area requires more than 1 grating section to cover area, clamp adjacent grating sections together at 1/4-points with fasteners acceptable to Engineer.
         8) Gaps between adjacent grating sections shall not be more than the clear spacing between bearing bars.
      e. When requested by Engineer, test 1 section of each size grating for each span length involved on the job under full load:
         1) Furnish a suitable dial gauge for measuring deflections.
      f. Grating shall be aluminum, unless otherwise specified or indicated on the Drawings.
   2. Aluminum grating:
      a. Material for gratings, shelf angles, and rebates: 6061-T6 or 6063-T6 aluminum alloy, except crossbars may be 6063-T5 aluminum alloy.
      b. Shelf angle concrete anchors: Type 304 or Type 316 stainless steel.
      c. Grating rebate rod anchors: 6061-T6 or 6063-T6 aluminum alloy.
d. Bar size and spacing: As determined by manufacturer to enable grating to support design load.

e. Design live load: A minimum of 100 pounds per square foot uniform live load on entire grating area, but not less than the live load indicated on the Drawings for the area where grating is located.

f. Maximum fiber stress for design load: 12,000 pounds per square inch.

g. Maximum deflection due to design load: 1/240 of grating clear span.

h. Maximum spacing of main grating bars: 1-1/8 inches clear between bars.

i. Minimum grating height: 1-1/2 inches.

j. Manufacturers: The following or equal:
   1) Harsco Industrial IKG, Grooved aluminum I-bar.

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

J. Stairs:
   1. Aluminum stairs:
      b. Stair treads:
         1) Aluminum of same type specified under Aluminum Grating.
         2) Of sizes indicated on the Drawings, and 1-3/4 inch minimum depth with cast abrasive type safety nosings.
      c. Handrails and guardrails: Aluminum pipe specified under Aluminum Handrails and Guardrails (Nonwelded Pipe).
      d. Fasteners: Type 304 or Type 316 stainless steel.

K. Miscellaneous aluminum:
   1. Fabricate aluminum products, not covered separately in this Section, in accordance with the best practices of the trade and field assemble by riveting or bolting.
   2. Do not weld or flame cut.

L. Miscellaneous cast iron:
   1. General:
      a. Tough, gray iron, free from cracks, holes, swells, and cold shuts.
      b. Quality such that hammer blow will produce indentation on rectangular edge of casting without flaking metal.
      c. Before leaving the foundry, clean castings and apply 16-mil dry film thickness coating of coal-tar epoxy, unless otherwise specified or indicated on the Drawings.

M. Miscellaneous stainless steel:
   1. Provide miscellaneous stainless steel items not specified in this Section as indicated on the Drawings or specified elsewhere.
      a. Fabricate and install in accordance with the best practices of the trade.
2. Cleaning and passivation:
   a. Following shop fabrication of stainless steel members, clean and
      passivate fabrications.
   b. Finish requirements: Remove free iron, heat tint oxides, weld scale and
      other impurities, and obtain a passive finished surface.
   c. Provide quality control testing to verify effectiveness of cleaning agents
      and procedures and to confirm that finished surfaces are clean and
      passivated.
      1) Conduct sample runs using test specimens with proposed cleaning
         agents and procedures as required to avoid adverse effects on
         surface finishes and base materials.
   d. Pre-clean, chemically descale (pickle), and final clean fabrications in
      accordance with the requirements of ASTM A380 to remove deposited
      contaminants before shipping.
      1) Passivation by citric acid treatment is not allowed.
         a) If degreasing is required before cleaning to remove scale or iron
            oxide, cleaning (pickling) treatments with citric acid are
            permissible; however, these treatments shall be followed by
            inorganic cleaners such as nitric-hydrofluoric acid.
      2) Provide acid descaling (pickling) in accordance with Table A1.1 of
      3) After pickling, final cleaning of stainless steel shall conform to Part II
         of Table A2.1 of Annex A2 of ASTM A380.
   e. After cleaning, inspect using methods specified for “gross inspection” in
      ASTM A380.
   f. Improperly or poorly cleaned and passivated materials shall not be
      shipped and will not be accepted at the job site.

N. Miscellaneous structural steel:
   1. Provide miscellaneous steel items not specified in this Section as indicated on
      the Drawings or specified elsewhere.
      a. Fabricate and install in accordance with the best practices of the trade.

O. Isolating sleeves and washers:
   1. As indicated on the Drawings and as specified in Section 05190 - Mechanical
      Anchoring and Fastening to Concrete and Masonry.

PART 3  EXECUTION

3.01 EXAMINATION

A. Verification of conditions:
   1. Examine work in place to verify that it is satisfactory to receive the work of
      this Section.
2. If unsatisfactory conditions exist, do not begin this work until such conditions have been corrected.

3.02 INSTALLATION

A. General:
   1. Install products as indicated on the Drawings, and in accordance with shop drawings and manufacturer's printed instructions, as applicable except where specified otherwise.
   2. Interface between materials:
      a. Dissimilar metals: Where steel comes in contact with dissimilar metals (aluminum, stainless steel, etc.), separate or isolate the dissimilar metals.
         1) Make application so that the isolating or protective barrier is not visible in the completed construction.
         2) Isolating sleeves and washers: As specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
      b. Aluminum in contact with concrete or masonry: Coat aluminum surfaces as specified in Section 09960 - High Performance Coatings.
      c. Aluminum in contact with concrete or masonry.

B. Aluminum stair nosing:
   1. Install stair nosings on treads of concrete stairs, including top tread on upper concrete slab.
   2. Omit stair nosings where concrete is submerged.

C. Cast iron stop plank grooves:
   1. Recess stop plank grooves with cast iron surfaces of groove set flush with concrete surface.

D. Handrails and guardrails:
   1. General:
      a. Fasten pipe rails to fittings with Series 300 stainless steel pop rivets or flush set screws.
      b. Make pipe cuts clean and straight, free of burrs and nicks, and square and accurate for minimum joint-gap.
      c. Drill and countersink holes to proper size, as required for a tight flush fit of screws and other component parts.
      d. Space attachment brackets as indicated in the manufacturer's instructions.
   2. Aluminum pipe handrails and guardrails:
      a. During construction, keep exterior surfaces of handrails and guardrails covered with minimum 0.4 millimeters of heat shrink polyethylene film.
b. Do not remove protective film before handrails and guardrails have been accepted by Engineer nor before other work in proximity of handrails and guardrails has been completed.
c. Discontinue handrails and guardrails at lighting fixtures.
d. Provide 1/8-inch diameter weep hole at base of each post.
e. Space posts as indicated on the Drawings.
f. Anchor posts into concrete by grouting posts into formed holes in concrete, into stainless steel sleeves cast in concrete; or bracket mount to face of concrete surfaces as specified and indicated on the Drawings.
g. Space rails as indicated on the Drawings.
h. Make adequate provision for expansion and contraction of kick plates and rails.
   1) Make provisions for removable sections where indicated on the Drawings.
i. Make lower rails a single, unspliced length between posts, or continuous.
j. Make top rails continuous whenever possible, and attach single, unspliced lengths to 3 posts minimum.
k. Draw up fasteners tight with hand wrench or screw driver.
l. Space attachment brackets as indicated on shop drawings or in manufacturer's installation instructions.
m. Completed installation shall have handrails and railings rigid and free of play at joints and attachments.
n. Protect handrail and guardrail finish from scratches, gouges, dents, stains, and other damage.
o. Replace damaged or disfigured handrails and guardrails with new.
p. Shortly before final acceptance of the work, and after removal of protective polyethylene film, clean handrails and guardrails with mild detergent or with soap and water.
   1) After cleaning, thoroughly rinse handrails and guardrails and wipe with soft cloth.
q. Erect guardrail straight, level, plumb, and true to the positions as indicated on the Drawings. Correct deviations from true line of grade, which are visible to the eye.

3. Guardrail gates:
   a. Install gate to be a vertical plane with the guardrail when in the closed position.
   b. Install hinges so that each gate can swing 180 degrees from the closed position to the fully open position.
   c. Install so that the gates swing to the walkway side of the guardrail only.
      1) Install gate stops on the stationary railing posts to prohibit gates from swinging in the wrong direction.
   d. Install gate frames, hinges, stops, and latches in conformance with OSHA minimum strength requirements.
E. Ladders:
   1. Secure to supporting surface with bent plate clips providing minimum 8 inches between supporting surface and center of rungs.
   2. Where exit from ladder is forward over top rung, extend side rails 3 feet 3 inches minimum above landing, and return the rails with a radius bend to the landing.
   3. Where exit from ladder is to side, extend ladder 5 feet 6 inches minimum above landing and rigidly secure at top.
   4. Erect rail straight, level, plumb, and true to position indicated on the Drawings:
      a. Correct deviations from true line or grade which are visible to the eye.

F. Manhole frames and covers:
   1. Installation: As specified in Section 02084 - Precast Drainage Structures.

G. Metal gratings:
   1. General:
      a. Allow 1/8-inch maximum clearance between ends of grating and inside face of vertical leg of shelf angles.
      b. Horizontal bearing leg of shelf angles shall be 2 inches minimum.
      c. Install aluminum plate or angles where necessary to fill openings at changes in elevation and at openings between equipment and grating.
      d. Install angle stops at ends of grating.
      e. Installed grating shall not slide out of rebate or off support.
      f. Weld stops in place, unless otherwise specified or indicated on the Drawings.
      g. Top surfaces of grating sections adjacent to each other shall lie in same plane.
   2. Aluminum grating:
      a. Aluminum grating: Support on aluminum shelf angles or rebates.

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

I. Stainless Steel:
   1. Welding:
      a. Passivate field-welded surfaces:
         1) Provide cleaning, pickling and passivating as specified in this Section.
         2) Clean using Derustit Stainless Steel Cleaner, or equal.

END OF SECTION
SECTION 07900
JOINT SEALANTS

PART 1    GENERAL

1.01 SUMMARY

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

1.02 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO):

B. ASTM International (ASTM):

1.03 SUBMITTALS

A. Product data.

B. Samples, include color selections.

C. Manufacturer's Installation Instructions.

D. Warranty.
1.04 QUALITY ASSURANCE

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

B. Installer qualifications: Manufacturer approved installer of products similar to specified products on minimum 5 projects of similar scope as Project with satisfactory performance record.

1.05 PROJECT/SITE CONDITIONS

A. Environmental requirements: Do not apply sealant on wet or frosty surfaces or when surface temperature is higher than 100 degrees Fahrenheit or lower than recommended by the manufacturer.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle products in accordance with manufacturer's recommendations.

B. Code date packages. Do not use material older than manufacturer’s published shelf life. Store materials at temperatures lower than 80 degrees Fahrenheit. Condition materials in accordance with manufacturer’s instructions prior to installation.

1.07 SEQUENCING AND SCHEDULING

A. Caulk joints prior to painting.

1.08 WARRANTY

A. Warrant to correct defective products for minimum 1 year in accordance with manufacturer's standard warranty.

PART 2 PRODUCTS

2.01 SEALANTS

A. General:
   1. Provide colors matching materials being sealed.
   2. Where compound is not exposed to view in finished work, provide manufacturer's color which has best performance.
   3. Nonsagging sealant for vertical and overhead horizontal joints.
   4. Sealants for horizontal joints: Self-leveling pedestrian/traffic grade.
   5. Joint cleaner, primer, bond breaker: As recommended by sealant manufacturer.
   6. Sealant backer rod and/or compressible filler made from closed cell polyethylene, polyethylene jacketed polyurethane foam, or other flexible,
nonabsorbent, non-bituminous material recommended by sealant manufacturer to:
   a. Control joint depth.
   b. Break bond of sealant at bottom of joint.
   c. Provide proper shape of sealant bead.
   d. Serve as expansion joint filler.

2.02 ACRYLIC-LATEX SEALANT

   A. Permanently flexible, nonstaining, and nonbleeding latex modified acrylic sealant compound, colors as selected by Engineer from manufacturer's standard options:
      1. Manufacturers: One of the following or equal:
         a. Tremco, Tremflex 834.
         c. Sonneborn, Sonolac.

2.03 PRECAST CONCRETE JOINT SEALANT

   A. Preformed, cold-applied, ready-to-use, flexible joint sealant in accordance with ASTM C990 and AASHTO M 198:
      1. Manufacturers: One of the following or equal.
         b. Concrete Sealants Division, ConSeal.

2.04 SILICONE SEALANT

   A. ASTM C920, Type S, Grade NS, Class 25, single component silicone sealant:
      1. Manufacturers: One of the following or equal:
         a. Tremco, Proglaze.
         b. Pecora Corp., Number 864.
         c. Dow Corning, Number 795.
         d. General Electric, Number 1200 Series.

2.05 SYNTHETIC RUBBER SEALING COMPOUND

   A. Manufacturer: One of the following or equal:
      1. Sika Corporation, Sikaflex 2c NS or SL
      2. Pacific Polymers, Elastothane 227R.

   B. Material: In accordance with ASTM C920 Type M, Grade P (pourable), Class 25 and Type M, Grade NS (non-sag), Class 25; multi-part polyurethane; able to cure at room temperature to firm, highly resilient polymer; able to perform satisfactory when continuously submerged in water or sewage and exposed to direct sunlight in dry condition; with the following properties determined at 75 degrees Fahrenheit and 50 percent relative humidity:
      2. Application time: Minimum 2 hours.
3. Cure time: Maximum 3 days.
4. Tack free time: Maximum 24 hours.
5. Ultimate hardness: Non-sag 25, Pourable/SL 40, within 5 Shore A.
6. Tensile strength: Non-sag 95 pounds per square inch minimum and self-leveling minimum 170 pounds per square inch when tested in accordance with ASTM D412.
7. Ultimate elongation: Minimum 340 percent when tested in accordance with ASTM D412.
8. Tear resistance: Non-sag 45 pounds per inch minimum and self-leveling minimum 85 pounds per inch when tested in accordance with ASTM D624, Die C.
9. Service temperature range: Minus 25 degrees to 158 degrees Fahrenheit.

C. Color: Gray to match concrete, unless indicated on the Drawings.

2.06 SYNTHETIC SPONGE RUBBER FILLER

A. Closed-cell expanded sponge rubber manufactured from synthetic polymer neoprene base, or resilient polyethylene foam backer rod. In accordance with ASTM C1330, Type C:
   1. Manufacturers: The following or equal:
      a. Presstite, No. 750.3 Ropax Rod Stock.

B. Characteristics:
   1. Suitable for application intended.
   2. Strength: As necessary for supporting sealing compound during application.
   3. Resiliency: Resistance to environmental conditions of installation.
   4. Bonding: No bonding to the sealing compound.
   5. Structure: Cellular, prevents absorption of water.
   6. Compatibility with other materials in joint and acceptance by manufacturer of sealing compound.
   7. Size: Minimum 25 percent greater than nominal joint width.

2.07 RELATED MATERIALS

A. Primer: Nonstaining type, recommended by sealant manufacturer to suit application.

B. Joint cleaner: Noncorrosive, nonstaining, compatible with joint forming materials and as recommended by sealant manufacturer.

C. Bond breaker tape: Pressure-sensitive tape recommended by sealant manufacturer to suit application.
PART 3 EXECUTION

3.01 EXAMINATION

A. Verify acceptability of joint dimensions, physical, and environmental conditions.

B. Verify that surfaces are dry, clean, and free of dirt, grease, curing compound, and other residue which might interfere with adhesion of sealants.

3.02 PREPARATION

A. Allow concrete to cure thoroughly before caulking.

B. Synthetic sponge rubber filler:
   1. Prepare surfaces designated to receive filler in accordance with manufacturer's installation instructions.
   2. Do not stretch filler beyond its normal length during installation.

C. Caulking:
   1. Verify that surfaces are dry, clean, and free of dirt, grease, curing compounds, and other residue that might interfere with adhesion of sealant.
   2. Concrete, masonry, wood, and steel surfaces: Clean and prime in accordance with manufacturer's instructions prior to caulking.

D. Synthetic rubber sealing compound:
   1. Ensure surfaces to which synthetic rubber must bond are dry and free of dust, dirt, and other foreign residue.
   2. Heavy sandblasted caulking groove to sound surface, and prime with manufacturer's recommended primer for particular surface.

E. For sidewalks, pavements, and similar joints sealed with elastomeric sealants and subject to traffic and other abrasion and indentation exposures, fill joints to depth equal to 75 percent of joint width, but neither more than 5/8 inch deep nor less than 3/8 inch deep.

F. For normal moving building joints sealed with elastomeric sealants not subject to traffic, fill joints to depth equal to 50 percent of joint width, but neither more than 1/2 inch deep nor less than 1/4 inch deep.

G. For joints sealed with acrylic-latex sealants, fill joints to depth in range of 75 percent to 125 percent of joint width.

H. Use joint filler to achieve required joint depths, to allow sealants to perform properly.

I. Prepare surfaces and install synthetic sponge rubber filler in accordance with manufacturer's recommendations.
J. Do not stretch filler beyond normal length during installation.

K. Apply bond breaker when recommended by joint sealer manufacturer.

3.03 INSTALLATION

A. Synthetic sponge rubber filler: Install filler in accordance with manufacturer's installation instructions.

B. Caulking, joints, and sealing:
   1. Construct expansion, contraction, and construction joints as indicated on the Drawings.
   2. Install pipe and conduit in structures as indicated on the Drawings.
   3. Caulk doors, windows, louvers, and other items installed in or over concrete openings inside and out.
   4. Use synthetic rubber sealing compound for caulking where indicated on the Drawings or as specified, except for masonry construction and where specified otherwise.
   5. Complete caulking prior to painting.
   6. Verify that concrete is thoroughly cured prior to caulking.
   7. When filler compressible material is used, use untreated type.
   8. Apply caulking with pneumatic caulking gun.
   9. Use nozzles of proper shape and size for application intended.
   10. Maintain continuous bond between caulking and sides of joint to eliminate gaps, bubbles, or voids and fill joint in continuous operation without layering of compound.
   11. Employ experienced applicators to caulk joints and seams in neat workmanlike manner.
   12. To hasten curing of compound when used on wide joints subject to movement, apply heat with infrared lamps or other convenient means.
   13. Apply synthetic rubber sealing compound with pneumatic caulking tool or other acceptable method.

3.04 CLEANING

A. Clean surfaces adjacent to sealant as work progresses.

B. Remove excess uncured sealant by soaking and scrubbing with sealant cleaning solvent.

C. Remove excess cured sealant by sanding with Number 80 grit sandpaper.

D. Leave finished work in neat, clean condition.
3.05 SCHEDULE

A. Acrylic latex:
   1. Use where indicated on the Drawings.
   2. Interior joints with movement less than 7.5 percent and not subject to wet conditions.

B. Silicone:
   1. Use where indicated on the Drawings.
   2. Joints and recesses formed where window, door, louver and vent frames, and sill adjoin masonry, concrete, stucco, or metal surfaces.
   3. Door threshold bedding.
   4. Moist or wet locations, including joints around plumbing fixtures.
   5. Stainless steel doors and frames, including joints between applied stops and frames, and around anchor bolts.
   6. Plenum joints.

C. Synthetic rubber sealing compound, non-sag Type II:
   1. Use where indicated on the Drawings.
   2. Water-bearing and earth-bearing concrete structures.
   4. Joints between sheet metal flashing and trim.
   5. Joints between sheet metal flashing and trim, and vertical wall surfaces.
   6. Small voids between materials requiring filling for weathertight performance in vertical surfaces.
   7. Perimeters of frames of doors, windows, louvers, and other openings where bonding is critical to airtight performance.
   8. Expansion and control joints in masonry vertical surfaces.

D. Synthetic rubber sealing compound, self-leveling Type I:
   1. Use where indicated on the Drawings.
   2. Expansion and control joints in masonry, concrete horizontal surfaces, and metal panels in horizontal surfaces.
   3. Small voids between materials requiring filling for weathertight performance in horizontal surfaces.
   4. Pavement joints.
   5. Perimeters of frames of doors, windows, louvers, and other openings in horizontal surfaces where bonding is critical to airtight performance.

3.06 FIELD QUALITY CONTROL

A. Adhesion testing:
   1. Perform adhesion tests in accordance with ASTM C1521 per the following criteria:
      a. Water bearing structures: 1 test per every 1,000 LF of joint sealed.
b. Exterior precast concrete wall panels: 1 test per every 2,000 LF of joint sealed.
c. Chemical containment areas: 1 test per every 1,000 LF of joint sealed.
d. Building expansion joints: 1 test per every 500 LF of joint sealed.
e. All other type of joints except butt glazing joints: 1 test per every 3,000 LF of joint sealed.
f. Manufacturer's authorized factory representative provide written recommendations for remedial measures on failing tests.

END OF SECTION
PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Coatings, including coating systems, surface preparation, application requirements, and quality control requirements.

1.02 REFERENCES

A. ASTM International (ASTM):

2. D2200 – Standard Practice for Use of Pictorial Surface Preparation Standards and Guides for Painting Steel Surfaces.
5. D4262 - Standard Test Method for pH of Chemically Cleaned or Etched Concrete Surfaces.
7. D4285 - Standard Test Method for Indicating Oil or Water in Compressed Air.
11. D4787 - Standard Practice for Continuity Verification of Liquid or Sheet Linings Applied to Concrete Substrates.
15. F1869 - Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride.
B. International Concrete Repair Institute (ICRI):
   1. 310.2 - Guideline for Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays, and Concrete Repair.

C. NACE International (NACE):
   2. SP0188 - Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates.

D. National Association of Pipe Fabricators (NAPF):
   1. 500-03 - Surface Preparation Standard for Ductile Iron Pipe and Fittings in Exposed Locations Receiving Special External Coatings and/or Special Internal Linings.

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

F. Occupational Safety and Health Administration (OSHA).

G. Society of Protective Coatings (SSPC):
   3. Guide 15 - Field Methods for Retrieval and Analysis of Soluble Salts on Steel and Other Nonporous Substrates.
   4. PA 1 - Shop, Field, and Maintenance Painting of Steel.
   5. PA 2 - Procedure for Determining Conformance to Dry Coating Thickness Requirements.
   7. QP 1 - Standard Procedure for Evaluating the Qualifications of Industrial/Marine Painting Contractors.
   8. SP 1 - Solvent Cleaning.
   9. SP 3 - Power Tool Cleaning.
   10. SP 5 - White Metal Blast Cleaning.
   11. SP 10 - Near-White Metal Blast Cleaning.
   12. SP 11 – Power Tools Cleaning to Bare Metal.
   13. SP 13 - Surface Preparation of Concrete.
   14. SP 16 - Brush-Off Blast Cleaning of Coated and Uncoated Galvanized Steel, Stainless Steels, and Non-Ferrous Metals.
   15. SP COM - Surface Preparation Commentary.
   16. SP VIS 1 - Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning.
   17. SP WJ-1 - Waterjet Cleaning of Metals -- Clean to Bare Substrate.
   18. SP WJ-2 - Waterjet Cleaning of Metals -- Very Thorough Cleaning.
   19. SP WJ-3 - Waterjet Cleaning of Metals -- Thorough Cleaning.
20. SP WJ-4 - Waterjet Cleaning of Metals -- Light Cleaning.

1.03 DEFINITIONS

A. Definitions used in this Section are in accordance with definitions referenced in ASTM D16, ASTM D3960, and SSPC Glossary of Definitions.

B. Specific definitions:
1. Abrasive: Material used for blast cleaning, such as sand, grit, or shot.
2. Abrasive Blast Cleaning: Cleaning/surface preparation by abrasive propelled at high speed.
3. Anchor Pattern: Profile or texture of prepared surface(s).
5. Bug Holes: Small cavities resulting when air bubbles are entrapped in the surface of formed concrete during placement and consolidation.
6. System: Protective film with 1 or more coats applied in a predetermined order, including surface preparation and quality control requirements.
7. Coating/Paint/Lining Thickness: Total thickness of primer, intermediate, and/or finish coats after drying or curing.
8. Dew point: Temperature a given air/water vapor mixture starts to condense.
10. Dry to Recoat: Time interval between material application and its ability to receive the next coat.
11. Dry to Touch: Time interval between material application and its ability to tolerate a light touch without coating damage.
12. Exposed Surface: Any indoor or outdoor surface not buried or encased.
13. Feather Edging: Reducing coating thickness at its edge to blend with existing surrounding coating.
14. Feathering: Tapering off a wet edge with a comparatively dry brush.
15. Ferrous: Cast iron, ductile iron, wrought iron, and all steel alloys except stainless steel.
16. Field Coat: Application of a surface coating system at the work site.
17. Finish Coat: Final coat in a paint system, including texture, color, smoothness of surface, and other properties affecting appearance.
18. Hold Point: A defined point, specified in this Section, at which work shall be halted for inspection.
19. Holiday: A discontinuity, skip, void, or pinhole in coating or coating system film that exposes the substrate.
20. Honeycomb: Segregated and porous surface of hardened concrete due to insufficient consolidation.
21. Hydroblast: High or ultra-high pressure water jet surface preparation.
22. Incompatibility: One coating’s inability to overlay another coating or surface as evidenced by bleeding, poor bonding, or lifting of old coating; inability of a coating to bond to a substrate.
23. Immerse/Immersion: A service condition in which substrate is submerged, is immediately above liquids, or is subject to frequent wetting, splashing, or washdown.


25. Mil: 0.001 inch.

26. Overspray: Dry spray, particularly paint bonded to an unintended surface.

27. Pinhole: A small diameter discontinuity in a coating or coating system film, created by offgassing from a void in a concrete or masonry substrate causing a void between coats or exposing the substrate. Usually caused by coating application while temperature is rising.

28. Pot Life: Time interval after components are mixed and coating can be satisfactorily applied.

29. Prime Coat: First full paint coat applied to a surface when using a multicoat system. Primers adhere to a new substrate, protect the substrate, and promote adhesion of subsequent coats of paint. The prime coat on metal surfaces is the first full coat and does not include solvent wash, grease emulsifiers, or other pretreatment applications.

30. Resurfacer/Resurfacing Material: A layer of cementitious and/or resin-based material used to fill or otherwise restore surface continuity to worn or damaged concrete surfaces.

31. Shelf Life: Maximum storage time a material may be stored without losing its usefulness.

32. Shop Coat: 1 or more coats applied in an off-site shop or plant before shipment to work site where field or finishing coat(s) are applied.

33. Spreading Rate: Area covered by a unit volume of paint at a specific thickness.

34. Stripe Coat: A separate brush coat of paint applied to all weld seams, pits, nuts/bolts/washers, and edges. This coat shall not be applied until previous coats have cured. Once applied, the coat shall be allowed to cure before subsequent coats are applied.

35. Tie Coat: An intermediate coat that bonds different types of paint material, improving succeeding coat adhesion.

36. Thick Film Coating System: A coating system applied with a minimum dry film thickness of 25 mils.

37. Touch-Up Painting: Application of paint on previously painted surfaces to repair marks, scratches, and deteriorated or damaged areas to restore the appearance and performance of the coating.

38. Water Blast: An alternative to air abrasive blast cleaning that can be used with or without abrasive injection. Water cleaning at pressures up to 5,000 pounds per square inch is called low-pressure water cleaning or power washing. High-pressure water cleaning uses water pressures between 5,000 and 10,000 pounds per square inch. Water jetting is water blasting with added abrasive at pressures between 10,000 and 25,000 pounds per square inch. Ultra-high-pressure water jetting is water blasting at pressures above 25,000 pounds per square inch.
39. **Weld Splatter**: Beads of non-structural weld metal that adhere to the surrounding surface, removed as part of surface preparation.

### 1.04 ABBREVIATIONS

A. **CSM** - Coating System Manufacturer.

B. **CMU** - Concrete Masonry Units.

C. **CSA** - Coating System Applicator. Specialty subcontractor retained by the Contractor to install the coating systems specified in this Section.

D. **CTR** - Coating System Manufacturer's Technical Representative.

E. **DFT** - Dry-Film Thickness. Thickness of cured film, usually expressed in mils (0.001 inch).

F. **SSD** - Surface Saturated Dry. Refers to concrete surface condition where the surface is saturated (damp) without the presence of standing water.

G. **TPC** - Technical Practice Committee.

H. **VOC** - Volatile Organic Compound. Portion of the coating that is a compound of carbon, is photochemically reactive, and evaporates during drying or curing; expressed in grams per liter (g/l) or pounds per gallon (lb/gal). VOC is determined by EPA Method 24.

I. **WFT** - Wet Film Thickness. Coating thickness as measured immediately after application. Usually expressed in mils (0.001 inch).

### 1.05 PERFORMANCE REQUIREMENTS

A. Coating materials shall be formulated for environments encountered in water and wastewater treatment processes.

### 1.06 SUBMITTALS

A. As specified in General Conditions, submit the following:
   1. Schedule of proposed coating materials.
   2. Schedule of surfaces to be coated with each coating material.
   3. Dehumidification and heating plan.
   4. Product data:
      a. Physical properties of coatings, including the following:
         1) Solids content.
         2) Ingredient analysis.
         3) VOC content.
         4) Temperature resistance.
5) Typical exposures and limitations.
6) Manufacturer's standard color chips.

b. Compliance with regulatory requirements:
   1) VOC limitations.
   2) Lead compounds and polychlorinated biphenyls.
   3) Abrasives and abrasive blast cleaning techniques and disposal.
   4) Methods for tenting blasting areas and methods to protect existing equipment from dust and debris.
   5) NSF certification of coatings for potable water supply systems.

c. CSM's current printed recommendations and product data sheets for coating systems, including:
   1) Surface preparation recommendations.
   2) Primer type.
   3) Maximum dry and wet-mil thickness per coat and number of coats.
      a) Coating Coverage Worksheets.
   4) Minimum and maximum curing time between coats, including atmospheric conditions for each.
   5) Curing time before submergence in liquid.
   6) Thinner to be used for each coating.
   7) Ventilation requirements.
   8) Minimum and maximum atmospheric conditions during which the paint shall be applied.
   9) Allowable application methods.
  10) Maximum allowable substrate moisture content.
  11) Maximum shelf life.
  12) Requirements for transportation and storage.
  13) Mixing instructions.
  14) Shelf life.
  15) Material Pot life.
  16) Precautions for applications free of defects.
  17) Method of application.
  18) Drying time of each coat, including prime coat.
  19) Compatible prime coats.
  20) Limits of ambient conditions during and after application.
  21) Required protection from sun, wind, and other conditions.
  22) Touch-up requirements and limitations.
  23) Minimum adhesion of each system submitted in accordance with ASTM D4541 and ASTM D7234.

d. Samples: Include 8-inch square drawdowns or brushouts of topcoat finish when requested. Identify each sample as to finish, formula, color name and number, sheen name, and gloss units.

e. Affidavits signed by an officer of the CSM’s corporation attesting to full compliance of each coating system component with current federal, state, and local air pollution control regulations and requirements.

f. List of cleaning and thinner solutions allowed by the CSMs.
g. Storage requirements, including temperature, humidity, and ventilation for Coating System Materials as recommended by the CSMs.

h. Thick film coating systems (greater than 25 mils):
   1) CSM’s detailed written instructions for coating system treatment and graphic details for coating system terminations in coated structures, including pipe penetrations, metal embedments, gate frames, and other terminations encountered.
   2) Include detail treatment for coating system at concrete joints.
   3) Manufacturer's Representative’s (CTR) Field Reports.

5. Quality assurance submittals:
   a. Quality assurance plan.
   b. Qualifications of CSA, including:
      1) List of Similar Projects.
         a) Name and address of project.
         b) Year of installation.
         c) Year placed in operation.
         d) Point of contact: Name and phone number.
      2) Provide a minimum of 5 project references, each including contact name, address, and telephone number where similar coating work has been performed by their company in the past 5 years.
   c. CSA Reports:
      1) Written daily quality control inspection reports.
   d. CTR Reports:
      1) Reports on visits to project site to view and approve surface preparation of structures to be coated.
      2) Reports on visits to project site to observe and approve coating application procedures.
      3) Reports on visits to coating plants to observe and approve surface preparation and coating application on shop-coated items.

1.07 QUALITY ASSURANCE

A. CSA qualifications:
   1. Minimum of 5 years of experience applying specified type or types of coatings under conditions similar to those of the Work:
      a. Provide qualifications of applicator and references listing 5 similar projects completed in the past 5 years.
   2. SSPC QP 1 certified.
   3. Manufacturer-approved applicator when manufacturer has approved applicator program or when required in these specifications.

B. CTR qualifications:
   1. Certification, one of the following:
      a. NACE Level 2 or 3 Certified Coating Inspector.
      b. SSPC Level 3 Protective Coatings Inspector.
2. Minimum of 5 years of experience applying manufacturer's coatings under conditions similar to those of the Work:
   a. Provide qualifications of applicator and references listing 5 similar projects completed in the past 5 years.

C. Regulatory requirements: Comply with governing agencies' regulations by using coatings conforming to their VOC limits.
   1. Lead-based coatings are not permitted.
   2. Do not use coal-tar epoxy in contact with drinking water or exposed to ultraviolet radiation.

D. Pre-installation conference: Conduct as specified in Section 01312 - Project Meetings.
   1. Coordinate Hold Point schedule

E. Obtain approval before coating other surfaces. Use products by same manufacturer for prime coats, intermediate coats, and finish coats on same surface, unless specified otherwise.

F. CSM services:
   1. CSA shall arrange for CTR to attend pre-installation conferences.
   2. Visit the project site periodically to consult on and inspect specified surface preparation and application Hold Points.
   3. Visit coating plants to observe and approve surface preparation procedures and coating application of items to be shop primed and coated.
   4. CTR shall provide written inspection reports.

G. Quality control requirements:
   1. Contractor shall be responsible for the workmanship and quality of the coating system installation.
      a. Inspections by District, Engineer, CSA, or CTR will not relieve or limit Contractor’s responsibilities.
   2. Conform to this specification's requirements and the standards referenced in this Section. Changes in the coating system application requirements will be allowed only with the Engineer's written acceptance.
   3. Specially trained crews with experience applying the specified coating system coating are required for:
      a. Coating application using plural component spray equipment or other specialty equipment.
      b. Coating with specialty linings for severe service conditions, including floor coatings, and with linings for corrosive headspaces or secondary containment areas.
   4. CTR shall specially train personnel for coating systems as specified in Appendix B Coating Detail Sheets.
      a. CSM shall approve personnel in writing applying the coating system.
5. Do not use contaminated, outdated, diluted materials, and/or materials from previously opened containers.
6. Identify inspection access points used by the District or Engineers.
7. Provide ventilation, ingress, egress, or other means as necessary for the District's or Engineer's personnel to safely access the work areas.
8. Conduct and continually inspect work so the coating system is installed as specified. The CSM shall provide written directions to correct coating work not conforming to the specifications or is otherwise unacceptable.
9. Provide written daily reports summarizing test data, work progress, surfaces covered, ambient conditions, quality control inspection test findings, and other information pertinent to the coating system application.
   a. Determine relative humidity in accordance with ASTM E337. Confirm other conditions, such as proper protective measures for surfaces not to be coated and safety requirements for personnel.
      1) Measure daily at shift's beginning and end and at intervals not to exceed 4 hours during the shift.
      2) Determine the acceptability of weather and/or environmental conditions within the structure in accordance with the CSM's requirements.
   b. Monitoring surface preparation: Spot check cleanliness, surface profile, and surface pH testing at least 3 times daily. Check each surface at least once. In accordance with:
      1) ASTM D4262.
      2) ASTM D4263.
      3) ASTM D4417.
      4) ICRI 310.2 requirements.
      5) SSPC Surface Preparation Standards.
   c. Confirm that compressed air used for surface preparation or blow-down cleaning is free of oil and moisture.
   d. Monitor surface preparation daily at shift's beginning and end and at intervals not to exceed 4 hours during the shift.
   e. Do not apply coatings when environmental conditions are outside of the CSM's published limits.
   f. Monitoring coatings application: Continuously inspect, measure, and record the wet film thickness and general film quality (visual inspection) for runs, sags, pinholes, holidays, etc. during coating.
      1) Perform WFT measurements in accordance with ASTM D4414.
   g. Post cure evaluation: Measure and inspect the overall dry film thickness on all surfaces. Conduct a DFT survey and perform adhesion testing, holiday detection, or cure testing as required in this Section and/or the CSM’s written instructions. Perform all applicable tests in accordance with ASTM D4541, ASTM D4787, ASTM D5162, ASTM D7234, SSPC-PA 1, SSPC-PA 2, SSPC-PA 9, and other pertinent standards and recommended practices.
H. Inspection at Hold Points:
   1. Conduct inspections at Hold Points during the coating system application and record the results.
   2. Coordinate Hold Points with the Engineer so the Engineer can observe Contractor’s inspections on a scheduled basis.
   3. Provide the Engineer a minimum of 24 hours of notice before conducting Hold Point Inspections.
   4. Hold Points shall be as follows:
      a. Conditions before surface preparation: Before starting surface preparation, observe, record, and confirm that oil, grease, and/or soluble salts are gone from the surface.
      b. Post surface preparation: After completing surface preparation, measure and inspect for cleanliness and proper surface profile as specified in this Section and in the CSM’s written instructions.
      c. Coatings application: At the beginning of any coating system application, measure, record, and confirm acceptability of surface and ambient air temperature and humidity. Inspect applicator's equipment for serviceability and suitability for coatings application.
      d. Coatings application: At the beginning of coating system application, measure, record, and confirm acceptability of surface and ambient air temperature and humidity. Inspect applicator's equipment for serviceability and suitability for coatings application.
         1) Observe conditions during the Pre-application Meeting.

1.08 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle products as specified in Section 01600 - Product Requirements.

B. Immediately remove unspecified and unapproved coatings from Project site.

C. Deliver new labeled, unopened containers:
   1. Do not deliver materials after manufacturer's expiration date or over 12 months from manufacturing date, whichever is more stringent. Store materials in well-ventilated enclosed structures and protect from weather and excessive heat or cold in accordance with the CSM’s recommendations.
      a. Store flammable materials in accordance with federal, state, and local requirements.
      b. Store rags and cleanup materials appropriately to prevent fire and spontaneous combustion.
   2. Store and dispose of hazardous waste in accordance with federal, state, and local requirements. This requirement specifically applies to waste solvents and coatings.
   3. Container labels shall show the following:
      a. Brand name or product title.
      b. CSM’s batch number.
c. CSM's manufacture date.
d. CSM's name.
e. Generic material type.
f. Application and mixing instructions.
g. Hazardous material identification label.
h. Shelf life expiration date.
i. Color.
j. Mixing and reducing instructions.

4. Clearly mark containers to indicate safety hazards associated with the use of or exposure to materials.

1.09 PROJECT CONDITIONS

A. Apply coatings to dry surfaces.
   1. Surface moisture: Comply with manufacturer's requirements or as specified in this Section.
      a. Concrete structures: Negative results from Plastic Sheet Test in accordance with ASTM D4263, and maximum of 80 percent relative humidity in accordance with ASTM F2170.

B. Do not apply coatings when the following conditions exist. If such conditions exist, provide containment, covers, environmental controls, and other necessary measures.
   1. During rainy, misty, or damp weather, or to surfaces with frost or condensation.
   2. When the surface temperature is below 10 degrees Fahrenheit above the dew point.
   3. When ambient or surface temperature:
      a. Is less than 55 degrees Fahrenheit unless manufacturer allows a lower temperature.
      b. Is less than 65 degrees Fahrenheit for clear finishes, unless manufacturer allows a lower temperature.
      c. Exceeds 90 degrees Fahrenheit, unless manufacturer allows a higher temperature.
      d. Exceeds manufacturer's recommendation.
   4. When relative humidity is higher than 85 percent.
   5. Under dusty or adverse environmental conditions.
   6. When light on surfaces measures less than 15 foot-candles.
   7. When wind speed exceeds 15 miles per hour.

C. Apply coating only under evaporation conditions rather than condensation.
   1. Use dehumidification equipment, fans, and/or heaters inside enclosed areas to maintain required atmospheric and surface temperature requirements for proper coating application and cure.
2. Measure and record relative humidity and air and surface temperatures at the start and end of each shift to confirm proper humidity and temperature levels inside the work area.
   a. Submit test results.

D. Continuously ventilate, dehumidify, and heat enclosed spaces with high humidity during surface preparation, coating application, and curing.
1. Maintain minimum air temperature of 55 degrees Fahrenheit and 10 degrees Fahrenheit above the dew point.
2. Maintain dew point of at least 10 degrees Fahrenheit less than the temperature of the coldest part of the structure where work is performed.
3. Reduce dew point temperature in conditioned space by at least 10 degrees Fahrenheit within 20 minutes.
4. Seal work areas and maintain positive pressure per dehumidification equipment supplier's recommendations.
5. Maintain these conditions before, during, and after application to ensure proper adhesion and cure of coatings for no less than:
   a. Entire curing period.
   b. 8 hours after coating.

E. Systems:
1. Site electrical power availability as specified in Section 01500 - Temporary Facilities and Controls.
2. Internal combustion engine generators may be used.
   a. Obtain required permits and provide air pollution and noise control devices on equipment as required by permitting agencies require.
   b. Comply with state, federal, and local fire and explosion protection measures when locating and operating generator.
   c. Locate engine generator outside hazardous classified areas per NFPA 820.
   d. Provide daily fuel service for generator for duration of use.
3. Dehumidification:
   a. Provide desiccant or refrigeration drying.
   b. Use only desiccant types with a rotary desiccant wheel capable of continuous operation.
   c. Liquid, granular, or loose lithium chloride drying systems are not acceptable.
4. Heating:
   a. Use electric, indirect combustion, or steam coil.
   b. Direct-fired combustion heaters are not acceptable heat sources during abrasive blasting, coating application, or coating cure.
5. Filters:
   a. Use a filtration system for dust removal designed to not interfere with dehumidification equipment’s ability to control dew point and relative humidity inside the reservoir.
   b. Do not allow air from the working area or dust filtration equipment to recirculate through their dehumidifier during coating application or when solvent vapors are present.

6. Design and submittals:
   a. Prepare and submit dehumidification and heating plan, including all equipment and operating procedures.
   b. Suppliers of services and equipment shall have at least 3 years of experience in similar applications.

F. Provide containment and ventilation system components in accordance with SSPC-Guide 6, Level 3 and as required for hazardous materials.

1.10 MAINTENANCE

A. Provide table of products applied organized by surface type. List coating manufacturer, color, color formulation, distributor name, telephone number, and address.

1.11 CTR RESPONSIBILITIES

A. General:
   1. Attend pre-installation conference.
   2. Perform onsite application training.
   3. Periodically inspect coating system application.

B. Coating system inspection:
   1. CTR inspection is in addition to the CSA's inspection as specified in this Section.
   2. Be on-site to oversee:
      a. Coating application at least once a week.
      b. End of surface preparation.
      c. During coating application.
      d. Post-cure inspection.
   3. Routinely inspect and verify in writing that application personnel have successfully performed surface preparation, filler/surfacer application, coating system application, and Quality Control Inspection in accordance with this Section and to warrantable quality.
   4. Perform the following activities to confirm conformance with the specifications:
      a. Inspect ambient conditions during coating system installation at Hold Points for conformance with the specified requirements.
b. Inspect each coated surface type and coating system applied to verify the following:
   1) Cleanliness.
   2) Surface pH for concrete substrates.
   3) Confirm surface preparation of substrates where coating system will terminate or will be applied for conformance to the specified application criteria.

c. Verify surface profile of substrates by completing the following:
   1) Inspect preparation and application of coating detail treatment at terminations, transitions, metal embedments in concrete, and joints and cracks in substrates.
   2) Inspect application of filler/surfacer materials for concrete and masonry substrates.
   3) Verify proper mixing of coating materials.
   4) Inspect application of primers and finish coats, including wet and dry film thickness.
   5) Inspect coating systems for proper cure times and conditions.

d. Review adhesion testing of cured coating systems.
e. Review coating system continuity testing.
f. Inspect and record representative-localized repairs.
g. Conduct final review of completed coating system installation.
h. Prepare and submit site visit reports after each site visit to document that the coating work is in accordance with the CSM’s Recommendations.

PART 2 PRODUCTS

2.01 MATERIALS

   A. General:
      1. Product requirements as specified in Section 01600 - Product Requirements.
2.02 COATING SYSTEMS IDENTIFICATION

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

<table>
<thead>
<tr>
<th>Table 1 Coating System Identification Elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Element</td>
</tr>
<tr>
<td>3 or 4 alpha characters</td>
</tr>
<tr>
<td>Coating Type</td>
</tr>
<tr>
<td>Example: EPX</td>
</tr>
</tbody>
</table>

1) First element identifies the coating type using the following abbreviations:
   a) ACR: acrylic.
   b) CTE: coal tar epoxy.
   c) ELA: elastomeric acrylic.
   d) EPU: epoxy-polyurethane.
   e) EPX: epoxy.
   f) POL: polyurethane.
   g) SIL: silicone.
   h) SILX: siloxane or silane.
   i) VE: vinyl ester.

2) Second element identifies the substrate using the following abbreviations:
   a) C: concrete or masonry.
   b) F: concrete flooring.
   c) FRP: fiber-reinforced plastic.
   d) GM: galvanized metal.
   e) M: metal.
   f) PVC: polyvinyl chloride, chlorinated polyvinyl chloride.

3) Third element identifies the sequential system number.
   a) For example, EPX-C-2 is the second standard epoxy coating system for concrete substrates.

4) Fourth element is optional and identifies the additional substrate or special condition with the following abbreviations:
   a) PWS: Potable water service applications (NSF-61 approved).
   b) BSC: Biogenic sulfide corrosion-resistant applications in wastewater.
   c) BG: Below grade or buried.
   d) OZ: Organic zinc primer, epoxy polyurethane system.
   e) SC: Secondary containment.
2.03 PRODUCTS FOR COATING SYSTEMS

A. Products: As specified in Appendix B Coating Detail Sheets.

B. Cleaning solvents:
   1. Requirements for solvent wash, solvent wipe, or cleaner used, including, but not limited to, those used for surface preparation in accordance with SSPC-SP 1:
      a. Emulsifying type.
      b. Containing no phosphates.
      c. Biodegradable.
      d. Does not damage zinc.
      e. Compatible with the specified primer.
      f. Complying with applicable air-quality control board requirements.
   2. Use clean white cloths and clean fluids in solvent cleaning.

PART 3 EXECUTION

3.01 GENERAL PROTECTION REQUIREMENTS

A. Protect adjacent coated surfaces from coatings and damage associated with coating work. Repair damage resulting from inadequate or unsuitable protection.

B. Use drop cloths and other coverings to protect adjacent surfaces not to be coated against spatter and droppings.

C. Mask off surfaces of items not to be coated or remove items from area.

D. Furnish and deploy sufficient drop cloths, shields, and protective equipment to prevent spray or droppings from fouling surfaces not being coated and, in particular, surfaces within storage and preparation areas.

E. Place coating waste, cloths, and material that may pose a fire hazard in closed metal containers and remove daily from site.

F. Remove electrical plates, surface hardware, fittings, and fasteners before coating application. Carefully store, clean, and replace items after completing coating in each area. Do not use solvent or degreasers to clean hardware that may remove permanent lacquer finishes.

G. Erect and maintain protective enclosures in accordance with SSPC- Guide 6.

H. Protect the following surfaces from abrasive blasting by masking or by other means:
   1. Threaded portions of valve and gate stems, grease fittings, and identification plates.
   2. Machined surfaces for sliding contact.
3. Surfaces to be assembled against gaskets.
4. Surfaces of shafting where sprockets will be fit.
5. Surfaces of shafting where bearings will be fit.
6. Machined bronze surfaces, including slide gates.
7. Cadmium-plated items, except cadmium-plated, zinc-plated, or sherardized fasteners used to assemble equipment requiring abrasive blasting.
8. Galvanized items, unless scheduled to be coated.

I. Protect installed equipment, mechanical drives, and adjacent coated equipment from abrasive blasting to prevent damage caused by spent abrasive blast media, dust, or dirt entering such equipment.

J. Schedule cleaning and coating to keep dust and spray from the cleaning process from falling on wet, newly coated surfaces.
   1. Whenever possible, coordinate with other trades and complete surface preparation and coating work before installing hardware, hardware accessories, nameplates, data tags, electrical fixtures, and similar uncoated items that will be in contact with coated surfaces. Mask machined surfaces, sprinkler heads, and other small items that will not be coated.
   2. After completing coating, reinstall removed items.
   3. Disconnect and move equipment adjacent to walls to clean and coat equipment and walls. Replace and reconnect equipment after coating.

3.02 GENERAL SURFACE PREPARATION REQUIREMENTS

A. Prepare surfaces in accordance with CSM's instructions unless more stringent requirements are specified in this Section.

B. Coating detail sheets in Appendix B include additional surface preparation requirements.

C. Follow more stringent requirement if information conflicts.

3.03 MECHANICAL AND ELECTRICAL EQUIPMENT PREPARATION

A. Identify equipment, ducting, piping, and conduit as specified in Section 15075 - Equipment Identification, Section 15076 - Pipe Identification, and Section 16075 - Identification for Electrical Systems.

B. Remove grilles, covers, and access panels for mechanical and electrical system and coat separately.

C. Prepare and finish coat equipment primed by the manufacturer using specified intermediate and top coats, as applicable, and color selected by the District.
D. Prepare, prime, and coat both insulated and bare pipes, conduits, boxes, insulated and bare ducts, hangers, brackets, collars, and supports, except where items are covered with material not requiring coating, or with a prefinished coating.

E. Replace identification markings on mechanical or electrical equipment when coated over or spattered.

F. Prepare and coat interior surfaces of air ducts and convector and baseboard heating cabinets visible through grilles and louvers with 1 coat of flat black paint to limit of sight line.

G. Prepare and coat dampers exposed immediately behind louvers, grilles, and convector and baseboard heating cabinets to match face panels.

H. Prepare and coat exposed conduit and appurtenances occurring in finished areas with color and texture to match adjacent surfaces.

I. Prepare and coat sides’ front, back, and edges of plywood backboards for electrical equipment before installing backboards and mounting equipment on them.

J. Color code equipment, piping, conduit, and exposed ductwork and apply color banding and identification, such as flow arrows, naming, and numbering, in accordance with the Contract Documents.

3.04 CLEANING OF NEW AND PREVIOUSLY COATED OR NEW SURFACES

A. Utilize cleaning agent to remove soluble salts, such as chlorides, from concrete and metal surfaces:
   1. Cleaning agent: Biodegradable non-flammable and containing no VOC.
   2. Manufacturers: The following or equal:
      a. CHLOR*RID International, Inc.
         1) Complete soluble salt removal with steam or warm water cleaning.
   3. Test cleaned surfaces to ensure removal of soluble salts. Carry out additional cleaning as needed.
   4. Complete final surface preparation before applying new coating system in strict accordance with CSM's printed instructions.

3.05 BLAST CLEANING

A. Surface preparation requirements:
   1. Do not reuse spent blast abrasive.
   2. Ensure that filter compressed air used for blast cleaning is free of condensed water and oil. Clean moisture traps at least once every 4 hours or more frequently, as required, to prevent moisture from entering the abrasive blasting equipment air supply. Check blast air for moisture and oil after each cleaning in accordance with ASTM D4285.
3. Install oil separators just downstream of compressor discharge valves and at the discharge point of blast pot discharges. Check separators on the same frequency as the moisture traps.

4. Keep regulators, gauges, filters, and separators on compressor air lines to blasting nozzles operational at all times.

5. Install an air dryer or desiccant filter drying unit to dry the compressed air before blast pot connections. Use and maintain the dryer throughout surface preparation work.

6. Use a venturi-type, or other high velocity-type, abrasive blast nozzles supplied with at least 100 pounds per square inch gauge air pressure at the nozzle and enough volume to obtain appropriate blast cleaning production rates and surface cleanliness.

7. Provide airborne particulate evacuation and filtering that meets OSHA safety standards. Maintain optimal visibility both to clean and provide the specified surface profile and to allow inspection of the substrate during surface preparation work.

8. If prepared and cleaned metallic substrates become contaminated between final surface preparation work and coating system application, or if the prepared substrate darkens or changes color, re-clean by water blasting, or abrasive blast cleaning as appropriate until the specified degree of cleanliness is restored.

B. Water jetting or water blasting:
   1. Use water jetting or water blasting for recoating or relining where an adequate surface profile exists.
   2. Perform water jetting or water blasting in accordance with SP 13 and SSPC-WJ-1, WJ-2, WJ-3, WJ-4.

3.06 PREPARATION REQUIREMENTS FOR CONCRETE SURFACES

A. Cure for at least 28 days before coating.

B. Remove degraded concrete using abrasive blast cleaning or high or ultrahigh pressure water jetting, chipping, or other abrading tools until achieving a sound, clean substrate. Remove all bruised or cracked concrete.

C. Prepare substrate cracks and areas requiring resurfacing; perform detail treatment, including, but not limited to, terminating edges per the CSM's recommendations and as indicated on the Drawings.
   1. Prepare concrete surfaces in accordance with SSPC-SP 13.

D. Prepare concrete surfaces in accordance with SSPC-SP 13.
   1. Inspect concrete surfaces to select appropriate surface preparation method to provide a suitable substrate for the specified coating system.
2. Use blast cleaning or other means to expose the complete perimeter of air voids or bug holes. Do not leave shelled over, hidden air voids beneath the exposed concrete surface.
3. Repair concrete defects and physical damage.
5. Fill voids to provide surface as specified in Section 03366 - Tooled Concrete Finishing.

E. Provide clean substrate visually free of calcium sulfate, loose, coarse, or fine aggregate, laitance, loose hydrated cement paste, and otherwise harmful substances.
   1. Confirm concrete surface minimum pH of 9.0 with surface pH testing.
   2. If after surface preparation the surface pH remains below 9.0, perform additional water blasting, cleaning, or abrasive blast cleaning until additional pH testing indicates an acceptable pH level.

F. Prepare concrete surface for coating in accordance with SSPC-SP 13.
   1. Provide ICRI 310.2 minimum No. 3 concrete surface profile (CSP) or as specified on Coating Detail Sheets.
   2. Evaluate profile of the prepared concrete using ICRI 310.2 surface profile replicas.

G. Blast clean cementitious repair mortars or grouts to the same profile and degree of cleanliness requirements required for concrete substrates.

H. Blast clean polymer-based surfaces or waterborne modified cementitious surfaces only if they have exceeded the CSM's recommended recoat time.

I. Vacuum all concrete surfaces before coating application, leaving a dust free, sound concrete substrate.
   1. Thoroughly clean concrete surfaces to be coated to remove loose dirt and spent abrasive.
   2. Remove debris produced by blast cleaning from the structures to be coated, and legally dispose of it off-site.

J. Test moisture content of concrete to be coated:
   1. Conduct ASTM D4263 plastic sheet test at least once for every 500 square feet of surface area to be coated.
      a. Any moisture on plastic sheet after test period constitutes a non-acceptable test, and the concrete must be dried further.
   2. Conduct ASTM F1869 test at least once for every 1,000 square feet of concrete floor surface area to be coated.
3. Conduct ASTM F2170 one relative humidity moisture test at least once for each 500 square feet of non-floor concrete surface area where the opposite side is exposed to soil or water.
   a. Waterproof surfaces exposed to soil or water.

4. Comply with specified minimum moisture content and CSM’s written recommendations for moisture vapor transmission rates or relative humidity values.

### 3.07 GENERAL PREPARATION REQUIREMENTS FOR METALLIC SURFACES

A. Remove rust, scale, and welding slag and spatter.
   1. Remove and grind smooth all excessive weld material and weld spatter on metal surfaces before blast cleaning in accordance with NACE SP0178, Appendix C, Level C.
   2. Grind sharp edges on metal substrate to approximately 1/16-inch radius before abrasive blast cleaning.

B. Prepare metallic surfaces in accordance with applicable portions of surface preparation specifications of the SSPC specified for each coating system.
   1. Remove grease and oil in accordance with SSPC-SP 1.
   2. Use solvent as recommended by the CSM.
   3. Measure profile depth of the surface to be coated in accordance with Method C of ASTM D4417. Contractor shall select blast particle size and gradation to produce the specified surface profile.
   4. Constantly monitor and maintain ambient environmental conditions to ensure cleanliness and that no “rust back” occurs before coating material application.

C. Prepare metallic surfaces by blast cleaning in accordance with SSPC-VIS 1 (ASTM D2200). Prepare abrasive blast representative areas for the District's representative to inspect on the first day of cleaning.

D. Unless otherwise specified, the requirements for blast cleaning steel, ductile iron, and stainless steel substrates are as follows:
   1. Ferrous metal surfaces not to be submerged: Abrasive blast in accordance with SSPC-SP 10 unless blasting may damage adjacent surfaces, is prohibited, or is specified otherwise. Where abrasive blasting is not possible, clean surfaces to bare metal with power tools in accordance with SSPC-SP 11.
   2. Ferrous metal surfaces to be submerged: Abrasive blast in accordance with SSPC-SP 5, unless specified otherwise, to clean and provide roughened surface profile with a depth between 2 and 4 mils.
   3. Remove traces of grit, dust, dirt, rust scale, friable material, loose corrosion products, or embedded abrasive from substrate before coating application.
   4. When abrasive blasted surfaces rust or discolor before coating, abrasive blast clean surfaces again.
E. Field preparation of shop-primed surfaces:
   1. Smooth welds and prominences with power tools before applying field-applied coatings.
   2. Clean and dry shop-primed ferrous metal surfaces and fabricated assemblies before applying field coats.
   3. Prepare shop epoxy primed surfaces with light abrasive blasting or abrading and then vacuum before applying finish coats.
      a. Follow CSM instructions for surface preparation when the primer recoat limit has been exceeded.
   4. Non-immersion service: Clean in accordance with SSPC-SP 2 (Hand Tool Cleaning) or SSPC-SP 3 (Power Tool Cleaning) and uniformly roughen.
   5. Immersion, BSC, and SC service: Remove shop primer in accordance with SSPC-SP 5 (Near-White Blast Cleaning).

F. Damaged shop primer or rust bleeding:
   1. Ferrous metals: Clean in accordance with SSPC-SP 1 (Solvent Cleaning) and spot blast in accordance with SSPC-SP 10 (Near-White Metal Blast Cleaning) to achieve a uniform surface profile between 2.0 and 2.5 mils before recoating.
   2. Reject galvanized steel with rust bleeding.

G. Damaged coating: Repair by abrasive blast cleaning surfaces as specified for the coating system; feather to a smooth transition before touching up.

3.08 PREPARATION REQUIREMENTS BY SURFACE TYPE

A. Ductile iron pipe and fittings to be lined or coated: Abrasive blast clean in accordance with NAPF 500-03.

B. PVC and FRP surfaces:
   1. Lightly sand surfaces to be coated.
      a. Sand to remove gloss and establish uniform surface profile.
   2. Vacuum to remove loose dust, dirt, and other materials.
   3. Solvent clean with clean white rags and allow solvent to evaporate completely before applying coating materials.

3.09 APPLICATION REQUIREMENTS

A. Apply coatings in accordance with manufacturer's instructions.

B. Empty aboveground piping to be coated of contents when applying coatings.

C. Mechanical equipment shop primed by the manufacturer.
   1. Pumps and valves: Shop coat with manufacturer's highest quality coating system meeting the project specifications.
      a. Contractor shall provide CTR shop coating reports.
2. Non-immersed equipment: Touch up shop primer, and coat in the field with specified coating system after installation.
   a. If project requires equipment removal and reinstallation, complete touch-up coating after final installation.
3. Immersed equipment not shop coated: Remove shop primer before surface preparation and field apply coating.

D. Verify surface preparation immediately before applying coating in accordance with SSPC SP COM and the SSPC visual standard for the specified surface preparation method.

E. Allow surfaces to dry, except where coating manufacturer requires surface wetting before coating.

F. Wash coat and prime sherardized, aluminum, copper, and bronze surfaces, or prime with manufacturer's recommended special primer.

G. Do not apply coatings to a surface until it has been prepared as specified.

H. Use equipment designed to apply materials specified.
   1. Use compressors with moisture traps and filters that remove water and oils from the air.
      a. Perform a paper blotter test at the Engineer's request to verify air is sufficiently free of oil and moisture. Do not allow the amount of oil and moisture to exceed CSM-recommended amount.
   2. Equip spray equipment with properly sized mechanical agitators, pressure gauges, pressure regulators, and spray nozzles.

I. Where 2 or more coats are required, tint prime coat intermediate coats as necessary to distinguish each coating and to help indicate coverage.
   1. Do not use color additives with chromium, lead or lead compounds that hydrogen sulfide, other corrosive gases, might destroy or alter. Apply the specified number of coats.

J. Apply coating by brush, roller, trowel, or spray unless a specific application method is required by coating manufacturer's instructions or these Specifications.
   1. Apply primer or first coat by brush to power tool cleaned ferrous surfaces.
   2. Brush or spray-apply coats for blast-cleaned ferrous surfaces and subsequent coats for non-blast cleaned ferrous surfaces.
   3. After prime coat dries, mark, repair, and retest pinholes and holidays before intermediate or top coats are applied.

K. Spray application:
   1. With a brush, stripe coat edges, welds, corners, nuts, bolts, and difficult-to-reach areas, as necessary, before spray application to ensure specified coating thickness along edges.
2. When using spray application, apply each coat to thickness no greater than recommended in coating manufacturer's instructions.
3. Use airless spray method unless air spray method is required by CSM's instruction or these Specifications.
4. Conduct spray coating under controlled conditions. Protect adjacent construction and property from coating mist, fumes, or overspray.

L. Lightly sand and thoroughly clean surfaces to receive high-gloss finishes unless CSM instructs otherwise.

M. Remove all dust on coatings between coats.

N. Shop and field coats:
1. Prime coat: Shop-apply or field-apply prime coats as specified. Use shop-applied primer compatible with the specified field coating system and apply at the minimum dry film thickness recommended by the finish coat CSM.
   a. Provide data sheets identifying the shop primer to on-site coating application personnel.
   b. Perform adhesion tests on the shop primer.
   c. Remove and recoat damaged, deteriorated, and poorly applied shop coatings.
   d. If shop primer coat meets this Section's requirements, spot prime exposed metal of shop-primed surfaces before spray applying primer over the entire surface.
2. Field coats: Apply field coats with 1 or more prime coats and finish coats to build up coating to dry film thickness specified for the coating system.
   a. Do not apply finish coats until other work in the area is complete and previous coats are inspected.
3. Adhesion confirmation: Perform adhesion tests after proper coating cure in accordance with ASTM D3359. Demonstrate that:
   a. Prime coat adheres to the substrate.
   b. Coatings adhere to the prime and intermediate coats.
      1) Coating 5 mils or more DFT: Achieve adhesion test result of 5A on immersed surfaces and 4A or better on other surfaces.
      2) Coating less than 5 mils DFT: Achieve adhesion test results of 5B on immersed surfaces and 4B or better on other surfaces.

O. Brush, roll, trowel, or spray and back roll coats for concrete and masonry.

P. Plural component coating application:
1. Premix contents of component drums if required by the CSM each day.
2. Before starting application:
   a. Verify gauges are working properly.
   b. Complete ratio checks.
c. Sample the mix on plastic sheeting to ensure set time is appropriate and complete.

d. Label and retain all spray samples. Submit to Engineer when requested.

Q. Drying and recoating:
1. Provide fans, heating devices, or other means to prevent condensate or dew on substrate surface or between coats and during curing after applying the last coat.
2. Allow each coat to cure or dry thoroughly, in accordance with if required in CSM’s printed instructions, before recoating.
3. Use CSM’s printed instructions and the requirements specified in this Section to determine minimum required drying time.
   a. Do not allow excessive drying time or exposure, which may impair bond between coats.
   b. Recoil all coatings within time limits recommended by CSM.
   c. If time limits are exceeded, abrasive blast clean and de-gloss clean before applying another coat.
4. If limitations on time between abrasive blasting and coating are not met before attaching components to surfaces that cannot be abrasive blasted, coat components before attachment.
5. Ensure primer and intermediate coats of coating are unscarred and completely integral when applying each succeeding coat.
6. Touch up suction spots between coats and apply additional coats where required to produce finished surface of solid, even color, free of defects.
7. Leave no holidays. Repair all holidays in accordance with the requirements on pertinent Coating Detail Sheets or as recommended by the CSM.
8. Sand and feather in to a smooth transition and recoat scratched, contaminated, or otherwise damaged coating surfaces so repairs are invisible to the naked eye.

R. Workmanship:
1. Ensure that coated surfaces are free from runs, drips, ridges, waves, laps, and brush marks. Coats shall be applied to produce a smooth, even film of uniform thickness completely coating corners and crevices.
2. Coat surfaces without drops, overspray, dry spray, excessive runs, ridges, waves, holidays, laps, or brush marks.
3. Remove splatter and droppings after coating work is completed.
4. Evenly apply each coat of material and sharply cut to a line created with masking tape or other suitable materials.
5. Avoid over spraying or spattering paint on surfaces not to be coated. Protect glass, hardware, floors, roofs, vehicles, and other adjacent areas and installations by taping, drop cloths, or other suitable measures.
6. When coating complex steel shapes, stripe coat welds, edges of structural steel shapes, metal cut-outs, pits in steel surfaces, or rough surfaces with the primer before overall coating system application.
   a. Brush apply stripe coat to ensure proper coverage.
   b. Do not stripe coat with spray or roller.
7. Ensure that finish coat, including repairs, has a uniform color and gloss.

S. Coating properties, mixing, and thinning:
1. Thin prime coat and apply as recommended by the CSM. Thinned coating must comply with prevailing air pollution control regulations.
2. If maximum recoat time is exceeded, prepare surface with solvent washing, light abrasive blasting, or other procedures per CSM’s instructions.
3. Allow adequate drying time between coats as instructed by the CSM, adjusted as necessary for the site conditions.
4. Ensure that coatings, when applied, provide a satisfactory film and a smooth even surface. Lightly sand glossy undercoats to provide a surface suitable for proper application and adhesion of subsequent coats. Thoroughly stir and strain coating materials during application and maintain uniform consistency.
5. Mix coatings with 2 or more components in accordance with CSM’s instructions.
6. Where necessary to suit conditions of the surface, temperature, weather and method of application, thin the coating per CSM’s recommendations.
   a. Ensure that volatile organic content (VOC) of the thinned coating complies with prevailing air pollution control regulations.
   b. Thin coatings to only what is necessary to obtain proper application characteristics.
   c. Use a thinner recommended by the CSM.

T. Film thickness and continuity:
1. Apply coating to the specified thicknesses.
   a. Apply additional coats when necessary to achieve specified thicknesses, especially at edges and corners.
2. Verify WFT of the coating system first coat and after applying each subsequent coat.
3. Do not allow the minimum thickness at any point to deviate more than 25 percent from the required average.
4. Do not allow the surface area covered per gallon of coating for various types of surfaces to exceed those recommended by the CSM.
   a. Provide coating coverage worksheets listing the maximum and minimum coverage for each unit volume of coating for concrete surfaces.
5. Apply additional coats to achieve the specified dry film thickness if brush or roller application methods cannot achieve the specified film thicknesses per coat.
U. Protecting coated surfaces:
   1. Do not handle, work on, or otherwise disturb coated items until the coating is completely dry and hard.
   2. After installation, recoat shop-coated surfaces with specified coating system as necessary to match surrounding surfaces, and to coordinate with the specified color identification requirements.

V. Special requirements:
   1. Before erection, apply all but the final finish coat to interior surfaces of roof plates, roof rafters and supports, pipe hangers, piping in contact with hangers, and contact surfaces inaccessible after assembly. Apply final coat after erection.
   2. Coat structural slip-critical connections and high strength bolts and nuts after erection.
   3. Areas damaged during erection:
      a. Prepare surface for spot repairs as specified for the coating system.
      b. Recount with prime coat before applying subsequent coats.
      c. Touch up surfaces after installation.
      d. Clean and dry surfaces to be coated at time of application.
   4. Coat underside of equipment bases and supports not galvanized with at least 2 coats of primer specified before setting the equipment in place.
   5. Coat aluminum in contact with concrete.

3.10 APPLICATION REQUIREMENTS FOR CONCRETE COATING SYSTEMS

A. Apply filler/surfacerr as recommended by CSM to fill bug holes and air voids in concrete or block texture in CMU, leaving a uniformly filled surface that does not produce blowholes or outgassing causing the coating system to pinhole.
   1. Allow filler/surfacers to cure sufficiently before applying prime coat as required by the CSM. Use the CSM-recommended drying time between coats.

B. Apply surfacer or filler and let dry before coating application.
   1. Use the drying time between filler/surfacers and coating system specified by the CSM for the site conditions.
      a. Let concrete substrate dry before applying filler/surfacers or coating system materials.
   2. If the maximum recoat time is exceeded, prepare surfaces by solvent washing, light abrasive blasting, and other procedures per CSM’s instructions.
   3. Apply a complete parg coat of the specified filler/surfacerr material over the entire substrate before applying the coating system.
      a. Scrob filler/surfacerr into the substrate to completely fill open air voids and bug holes.
      b. Completely cover the substrate, unless otherwise specified, above such filled voids by 1/8 inch of thickness.
      c. Provide relatively flat, uniformly even surface before coating application.
4. Secondary containment: Place surfacer or filler 1/16 inch thick above concrete plane to create a monolithic surface free of pinholes.
   a. Floor surfaces: Broadcast with aggregate to create a non-slip surface texture.
   b. Remove excess aggregates and apply base coat to encapsulate embedded non-slip aggregate.

C. Concrete substrate temperatures:
   1. Apply filler/surfacers and the coating system when temperatures are falling, typically late afternoon or evening.
      a. Do not coat concrete with rising concrete substrate surface temperatures or substrates in direct sunlight, to minimize outgassing from the substrate and formation of pinholes, and/or blistering.
   2. Should bubbles, pinholes, or other discontinuities form in the applied coating system material, they shall be repaired.
      a. Should discontinuities develop in the filler/surfacer material or in the first coat of the coating material, repair them before the next coat.
      b. When discontinuities occur, open the air void behind or beneath the discontinuities and completely fill with specified coating material. Then, abrade the coated area around the discontinuities repair reapply coating over that area.

D. Perform application detail work in accordance with these Specifications, the CSM’s current written recommendations, and drawings, whichever is stricter.

E. Concrete coating systems application requirements:
   1. Concrete coating minimum dry film thickness excludes parge coat, block filler, and sealer.

3.11 COATING SYSTEM SCHEDULE

A. Appendix A specifies surfaces to be coated in the field with the coating systems required.

3.12 Surfaces NOT Requiring coating

A. Stainless steel piping, valves, pipe supports, instrument sunshades.

B. Sliding surfaces on expansion joints, motor and pump shafts, machined surfaces at bearings and seals, grease fittings, etc.

C. Galvanized structural steel framing, galvanized roof decking, galvanized pipe supports.

D. Copper and brass pipe, fittings, valves, etc.

E. Bronze valves, bearings, bushings, and fasteners.
F. Corrosion resistant special alloys: Inconel, Alloy 20, Hastelloy, etc.

G. Exterior Concrete.

H. Plastic surfaces except coat PVC, CPVC, and other plastic piping system exposed to sunlight.

I. Buried Piping that is encased in concrete or cement mortar.

### 3.13 Quality control

A. District-provided inspection or inspection by others does not limit the Contractor’s or CSA’s responsibilities for quality workmanship or quality control as specified or as required by the CSM’s instructions. District inspection is in addition to any inspection required of the Contractor.

B. District may perform, or contract with an inspection agency to perform, quality control inspection and testing of the coating work covered by this Section. These inspections may include the following:
   1. Inspect materials upon receipt to ensure that the CSM supplied them.
   2. Verify that specified storage conditions for the coating system materials, solvents, and abrasives are provided.
   3. Inspect and record findings for substrate cleanliness.
   4. Inspect and record pH of concrete and metal substrates.
   5. Inspect and record substrate profile (anchor pattern).
   6. Measure and record ambient air and substrate temperature.
   7. Measure and record relative humidity.
   8. Check for substrate moisture in concrete.
   9. Verify that mixing of coating system materials is in accordance with CSM’s instructions.
   10. Inspect, confirm, and record that coating system materials’ "pot life" is not exceeded during installation. Inspect to verify that recoat limitations for coating materials are not exceeded.
   11. Perform adhesion testing.
   12. Measure and record the coating system's thickness.
   13. Verify proper curing of the coating system in accordance with the CSM's instructions.
   14. Holiday or continuity testing in accordance with NACE SP0188 for coatings that will be immersed or exposed to aggressively corrosive conditions.

C. Contractor shall perform holiday testing in accordance with NACE SP0188 to identify holidays or pinholes needing repair for coating over 100 percent of surfaces:
   1. Coated steel that will be immersed or exposed to aggressively corrosive conditions.
   2. Coated concrete.
3. Perform holiday tests after proper application and coating system cure.

### 3.14 Corrective Measures

A. Repair pinholes or holidays identified by Holiday Testing as follows:
   1. Remove the coating system with a grinder or other suitable power tool.
   2. Remove coating system at all pinholes and holidays at least 2 inches diameter around the defect back to expose substrate.
   3. Concrete voids: chip back to expose entire cavity in all directions.
      a. Completely fill void with approved filler/surfacer material using a putty knife or other suitable tool, and strike off. Cure per CSM’s recommendations.
   4. Aggressively abrade or sand the intact coating system surface at least 3 inches beyond the removal area in all directions to produce a uniform 6- to 8-mil profile in the intact coating system.
   5. Vacuum the prepared area to remove all dust, dirt, etc., leaving clean, sound surfaces.
   6. Tape to mask the periphery of the prepared intact coating area to prevent coating repair application onto the prepared area.
   7. Apply the coating system with enough coats to achieve the specified finish coat thickness over the defect and coating removal area. Feather the coating onto the abraded coated surfaces around the removal area to avoid a lip and to achieve a neat repair outline.
   8. Follow curing time between coats as specified by CSM for the site conditions. Solvent wash and abrasive blast per CSM’s instructions, if the maximum recoat time is exceeded.
   9. Apply coating at specified dry film thickness.

### 3.15 CLEANUP

A. Remove surplus materials, protective coverings, and accumulated rubbish after completing coating. Thoroughly clean surfaces and repair overspray or other coating-related damage.

### 3.16 FINAL INSPECTION

A. Conduct final inspection of coating system work to determine whether it meets specifications requirements.

B. Conduct subsequent final inspection with Engineer to ensure work conforms to contract documents requirements.

C. Mark any rework required.
   1. Re-clean and repair, as specified, at no additional cost to the District.

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

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPU-M-1</td>
<td>Metals, exterior, non-immersed</td>
</tr>
<tr>
<td>EPX-M-2</td>
<td>Metals, interior, non-immersed</td>
</tr>
<tr>
<td>EPX-C-2</td>
<td>Concrete, immersed</td>
</tr>
<tr>
<td>ACR-PVC-1</td>
<td>0</td>
</tr>
</tbody>
</table>

Notes:

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

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

### Coating System
- EPU-M-1

### Coating Material
- Two coats epoxy with polyurethane finish coat

### Substrate Products
<table>
<thead>
<tr>
<th>Products</th>
<th>Primer</th>
<th>Intermediate Coat</th>
<th>Finish Coat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carboline</td>
<td>Carboguard 890</td>
<td>Carboguard 890</td>
<td>Carbothane 134 MC</td>
</tr>
<tr>
<td>International Paint</td>
<td>Devran 224V</td>
<td>Devran 224V</td>
<td>Devthane 379H</td>
</tr>
<tr>
<td>PPG</td>
<td>Amerlock 2/400 VOC</td>
<td>Amerlock 2/400 VOC</td>
<td>Amershield VOC</td>
</tr>
<tr>
<td>Sherwin Williams</td>
<td>Macropoxy 646 100</td>
<td>Macropoxy 646 100</td>
<td>Hi Solids Polyurethane 100</td>
</tr>
<tr>
<td>Tnemec</td>
<td>Series L69</td>
<td>Series L69</td>
<td>Series 1095</td>
</tr>
</tbody>
</table>

### Service Condition
- Interior or Exterior, subject to direct sunlight. Non-immersion.

### Surface Preparation

#### General
- Prepare surfaces as specified in this Section and as follows.

#### Ferrous Metal
- Bare surfaces: SSPC-SP10, Near-White Blast Cleaning.
- Shop primed surfaces: SSPC-SP2, Hand Tool Cleaning or SSPC-SP3, Power Tool Cleaning.
- Damaged primer or rust: SSPC-SP10, Near White Blast Cleaning and spot prime.

#### Nonferrous Metal
- SSPC-SP16, Brush Blast Cleaning.

#### Galvanized Metal
- SSPC-SP16, Brush Blast Cleaning. Test for surface contaminants.

### Surface profile
- Ferrous Metal: 2.5 to 3.0 mils
- Nonferrous Metal: 1.5 to 2.0 mils
- Galvanized Metal: 1.5 to 2.0 mils

### System Thickness (Dry Film)
- Total: 10 to 13 mils
- Primer: 4 to 5 mils
- Intermediate Coat: 4 to 5 mils
- Finish Coat: 2 to 3 mils

### Application
- Special CTR Training: Not required.
<table>
<thead>
<tr>
<th>Coating System</th>
<th>EPX-M-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coating Material</td>
<td>Epoxy</td>
</tr>
<tr>
<td>Substrate</td>
<td>Metal</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Products</th>
<th>Primer</th>
<th>Intermediate Coat</th>
<th>Finish Coat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carboline</td>
<td>Carboguard 890VOC</td>
<td>Carboguard 890VOC</td>
<td>Carboguard 890VOC</td>
</tr>
<tr>
<td>International Paint</td>
<td>Bar-Rust 231 LV</td>
<td>Bar-Rust 231 LV</td>
<td>Bar-Rust 231 LV</td>
</tr>
<tr>
<td>PPG</td>
<td>Amerlock 2/400 VOC</td>
<td>Amerlock 2/400 VOC</td>
<td>Amerlock 2/400 VOC</td>
</tr>
<tr>
<td>Sherwin Williams</td>
<td>No product specified</td>
<td>No product specified</td>
<td>No product specified</td>
</tr>
<tr>
<td>Tnemec</td>
<td>Series L69</td>
<td>Series L69</td>
<td>Series L69</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Service Condition</th>
<th>Immersed, non-immersed, moderately corrosive environment.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Surface Preparation</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>Prepare surfaces as specified in this Section and as follows.</td>
</tr>
<tr>
<td>Ferrous Metal</td>
<td>Bare surfaces: SSPC-SP5, White Metal Blast Cleaning. Shop primed surfaces: SSPC-SP7, Brush-Off Blast Cleaning. Damaged primer or rust: SSPC-SP5, White Metal Blast Cleaning and spot prime.</td>
</tr>
<tr>
<td>Nonferrous Metal</td>
<td>SSPC-SP16, Brush-Off Blast Cleaning;</td>
</tr>
<tr>
<td>Galvanized Metal</td>
<td>SSPC-SP16, Brush-Off Blast Cleaning;</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Surface profile</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ferrous Metal</td>
<td>2 to 4 mils</td>
</tr>
<tr>
<td>Nonferrous Metal</td>
<td>1.0 to 1.5 mils</td>
</tr>
<tr>
<td>Galvanized Metal</td>
<td>1.0 to 1.5 mils</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>System Thickness (Dry Film)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>12 to 16 mils</td>
</tr>
<tr>
<td>Primer</td>
<td>4 to 6 mils</td>
</tr>
<tr>
<td>Intermediate Coat</td>
<td>4 to 6 mils</td>
</tr>
<tr>
<td>Finish Coat</td>
<td>4 to 6 mils</td>
</tr>
</tbody>
</table>

<p>| Application | Special CTR Training Not required. |</p>
<table>
<thead>
<tr>
<th>Coating System</th>
<th>EPX-C-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coating Material</td>
<td>Epoxy</td>
</tr>
<tr>
<td>Substrate</td>
<td>Concrete or masonry</td>
</tr>
<tr>
<td>Products</td>
<td></td>
</tr>
<tr>
<td>Carboline</td>
<td>Primer</td>
</tr>
<tr>
<td>International Paint</td>
<td>Bar-Rust 231 LV</td>
</tr>
<tr>
<td>PPG</td>
<td>Amerlock 2 VOC</td>
</tr>
<tr>
<td>Sherwin Williams</td>
<td>Macropoxy 646-100</td>
</tr>
<tr>
<td>Tnemec</td>
<td>Series L69</td>
</tr>
<tr>
<td>Service Condition</td>
<td>Interior, Non-Immersion, Moderately Corrosive.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Surface Preparation</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete</td>
<td>Prepare surfaces as specified in this Section and as follows. Cure at least 28 days and dry to the CSM's recommended moisture content. Remove loose concrete and laitance from surfaces, and repair voids and cracks as specified in this Section.</td>
</tr>
<tr>
<td>Existing Coated Concrete</td>
<td>Remove all existing coating to a sound substrate or intact, well-adhered coating. Abrade all surfaces to achieve required surface profile and vacuum to remove all loose dirt, paint chips, and dirt.</td>
</tr>
<tr>
<td>Masonry</td>
<td>Cure at least 28 days and dry to CSM's recommended moisture content. Fill holes or other joint defects with mortar and repaint. Scrape or chip to remove loose or splattered mortar. Wash and scrub masonry surfaces with clear water to remove foreign and deleterious substances. Do not use muriatic acid. Fill surfaces with block filler compatible with the specified primer after cleaning.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Surface profile</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete</td>
<td>0.5 to 1.5 mils</td>
</tr>
<tr>
<td>Existing Coated Concrete</td>
<td>0.5 to 1.5 mils</td>
</tr>
<tr>
<td>Masonry</td>
<td>0.5 to 1.5 mils</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>System Thickness (Dry Film)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>10 mils, excluding block filler and sealer.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Application</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>Let sealer or filler dry at least 48 hours before primer application. Use CSM's recommended drying time between coats.</td>
</tr>
<tr>
<td>Special CTR Training</td>
<td>Not Required.</td>
</tr>
</tbody>
</table>
## Coating Detail Sheet

<table>
<thead>
<tr>
<th>Coating System</th>
<th>ACR-PVC-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coating Material</td>
<td>Acrylic</td>
</tr>
<tr>
<td>Substrate</td>
<td>PVC and CPVC pipe</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Products</th>
<th>Primer</th>
<th>Intermediate Coat</th>
<th>Finish Coat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carboline</td>
<td>Sanitile 120</td>
<td>None Applied</td>
<td>Carbocrylic 3359 MC</td>
</tr>
<tr>
<td>International Paint</td>
<td>Devcryl 1440</td>
<td>None Applied</td>
<td>Devcryl 1448</td>
</tr>
<tr>
<td>PPG</td>
<td>Pitt Tech Plus Primer</td>
<td>None Applied</td>
<td>Pit Tech Plus</td>
</tr>
<tr>
<td>Sherwin Williams</td>
<td>A24WA300</td>
<td>None Applied</td>
<td>Metalatex</td>
</tr>
<tr>
<td>Tnemec</td>
<td>Series 1028 or 1029</td>
<td>None Applied</td>
<td>Series 1028 or 1029</td>
</tr>
</tbody>
</table>

| Service Condition | Exterior, exposed to direct sunlight, non-immersed. |

<table>
<thead>
<tr>
<th>Surface Preparation</th>
<th>Prepare surfaces as specified in this Section and as follows.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General</strong></td>
<td>Clean to remove loose dirt, dust, or other contaminants.</td>
</tr>
<tr>
<td></td>
<td>Sand surfaces to achieve a uniform, roughened surface profile.</td>
</tr>
<tr>
<td></td>
<td>Solvent clean and vacuum to remove loose debris.</td>
</tr>
<tr>
<td>Surface profile</td>
<td>1.5 to 2.0 mils</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>System Thickness (Dry Film)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
</tr>
<tr>
<td>Primer</td>
</tr>
<tr>
<td>Finish Coat</td>
</tr>
</tbody>
</table>

| Application | Special CTR Training | Not Required. |
SECTION 10400
SIGNAGE

PART 1  GENERAL

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

1.02  REFERENCES
A. National Fire Protection Association (NFPA):
B. Occupational Safety and Health Administration (OSHA).

1.03  SUBMITTALS
A. Product data.
B. Shop drawings: Include lists of sign types, sizes, text, and colors; mounting details; locations; and cast metal plaque rubbings and templates.
C. Samples: Include actual materials.
D. Manufacturer's installation instructions.

1.04  QUALITY ASSURANCE
A. Manufacturer qualifications: Manufacturer of proposed products for minimum 5 years with satisfactory performance record of minimum 5 years.
B. Installer qualifications: Manufacturer approved installer of products similar to specified products on minimum 10 projects of similar scope as Project with satisfactory performance record.
C. Regulatory requirements: Provide signage in accordance with Americans with Disabilities Act as published in the Federal Register, Volume 56, No. 144, Friday, July 26, 1991.
PART 2 PRODUCTS

2.01 METAL SAFETY SIGNS

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

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

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

D. Safety instruction signs:
   2. Heading: White lettering on green rectangular panel.
   4. Size: As scheduled.

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

F. Notice information signs:
   2. Heading: White lettering on blue rectangular panel.
   4. Size: As scheduled.

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

H. See Schedule B for specific sign size, location, text, and quantity.

2.02 EXTERIOR INFORMATION SIGNS

A. Able to withstand 100 miles per hour wind load without damage:
1. Manufacturers: One of the following or equal:
   a. Best Manufacturing Sign Systems; equivalent product.
   b. Andco Industries Corp., equivalent product.
   c. Vomar Products, Inc., equivalent product.

B. Sign panel: Nominal 3 inches thick, consisting of 1/8-inch thick fiberglass material with integral returns fully encapsulating wood and foam core, 1/8-inch radius edges and corners, size as indicated on the Drawings.

C. Text: Helvetica medium, size and wording as indicated on the Drawings.

D. Posts: Nominal 3 inch square extruded aluminum sections with aluminum fillers at top and bottom, mounting hardware, and aluminum baseplates drilled for anchor bolts.

E. Fasteners: Manufacturer's standard, suitable for application.

F. Colors: As selected from manufacturer's standard colors.

PART 3  EXECUTION

3.01 PREPARATION

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

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

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

3.02 INSTALLATION

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

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

C. Install signs where indicated on the Drawings.

END OF SECTION
SCHEDULE A

PLASTIC SIGNAGE SYSTEM SCHEDULE

A. Nonpotable Water:
   1. Location: At impure water and nonpotable water hose valves in accordance with Typical Detail M276.
   2. Height: In accordance with Typical Detail.
   3. Size: 10 inches wide by 7 inches high.
   4. Heading: CAUTION
   5. Text: IMPURE WATER
             DO NOT DRINK

END OF SCHEDULE A

PLASTIC SIGNAGE SYSTEM SCHEDULE
SCHEDULE B

METAL SAFETY SIGN SCHEDULE

B. NONPOTABLE WATER:
   1. Location: At impure water and nonpotable water hose valves in accordance with Typical Detail M276.
   2. Height: In accordance with Typical Detail.
   3. Size: 10 inches wide by 7 inches high.
   4. Heading: DANGER
   5. Wording: DO NOT DRINK THIS WATER

C. REMOTELY CONTROLLED AUTOMATIC EQUIPMENT:
   1. Location: On front and back of equipment that starts automatically.
   2. Height: Five feet above floor elevation.
   3. Size: 10 inches wide by 7 inches high.
   4. Heading: CAUTION
   5. Wording: THIS EQUIPMENT STARTS & STOPS AUTOMATICALLY

D. CONFINED SPACE
   1. Location: Stenciled on all manhole covers and Area 24 Storm Drain Pump Station.
   2. Height: Five feet above floor elevation.
   3. Size: 10 inches wide by 7 inches high.
   4. Heading: DANGER
   5. Wording: PERMIT REQUIRED CONFINED SPACE DO NOT ENTER

END OF SCHEDULE B
METAL SAFETY SIGN SCHEDULE
SECTION 11294B

HEAVY-DUTY FABRICATED STAINLESS STEEL SLIDE GATES

PART 1  GENERAL

1.01  SUMMARY

A. Section includes: Heavy-duty fabricated stainless steel slide gates.

B. As specified in Section 01600 - Product Requirements.

1.02  REFERENCES

A. American Water Works Association (AWWA):
   2. C561 - Fabricated Stainless Steel Slide Gates.

B. ASTM International (ASTM):

1.03  DEFINITIONS

A. Slenderness ratio (l/r): The largest ratio obtained by dividing the unsupported length of the stem by the radius of gyration of the stem cross section.

B. Design head: Depth from surface of water to centerline of gate. Use value specified in the gate schedule.

C. Seating head: Pressure applied to gate slide from weight of water column above gate centerline that forces gate slide into seat.

D. Unseating head: Pressure applied to gate slide from weight of water column above gate centerline that forces gate slide away from seat.

E. Substantially similar:
   1. Similar in size, design head, and service.
2. Utilizes the proposed design for critical components including guides and seals.

1.04 DESIGN REQUIREMENTS

A. Except as modified or supplemented as specified in this Section, all gates and operators shall conform to the requirements of AWWA C561, latest edition.

B. Gate components:
   1. Frames:
      a. Design for the design head scheduled with a minimum safety factor of 5 with regard to ultimate tensile, compressive, and shear strength.
      b. Self-contained gates: Where frames extend above the operating floor, design to be self-supporting so that no further reinforcing or support is required.
   2. Stem: Select stem diameter, stem guide quantity and stem guide spacing based on following criteria:
      a. Slenderness ratio (\(l/r\)): Shall not exceed 200.
      b. Maximum diameter: Provide stem guides at a spacing to maintain stem diameter of 2 inches or less.
      c. Tensile strength: Suitable to withstand the force generated by the operator with the application of a 200-pound force applied to the crank or handwheel or a 250-foot-pound torque applied to the wrench nut.
      d. Compressive strength:
         1) Suitable to withstand buckling due to the force generated by the operator with the application of an 80-pound force applied to the crank or handwheel or a 100-foot-pound torque applied to the wrench nut.
         2) Determine buckling load using Euler Column formula in accordance with AWWA C 561, where \(C = 2\).
      e. Design force for power actuators:
         1) Hydraulic cylinder operators: 1.25 times the output thrust at maximum hydraulic fluid operating pressure.
         2) Electric motor operators: 1.25 times the output thrust in the stalled-motor condition.
      f. Gates having widths greater than 2 times the height: Provide with 2 lifting mechanisms connected by a tandem shaft.
   3. Thrust nut: Suitable to withstand thrust developed by operator with the application of a 40-pound force on the crank or handwheel with safety factor of 5. Base design on ultimate strength of material used.
   4. Yokes for self-contained gates:
      a. Design yoke using design loading criteria for stem with safety factor of 5 based on the ultimate strength of the material used.
      b. Maximum deflection at design load: Not to exceed 1/360th of the span.
5. Slide:
   a. Deflection shall be less than or equal to $1/1000$ of the span of the gate or $1/16$ inch, whichever is less, when under the design head.
   b. Design for the maximum design head specified with a minimum safety factor of 5 with regard to ultimate tensile, compressive, and shear strength.

1.05 PERFORMANCE REQUIREMENTS

A. Maximum allowable leakage shall be 0.05 gallon per minute per foot of sealing perimeter, half the allowable limit set forth in AWWA C561. Leakage testing shall be conducted in accordance with AWWA C561.

1.06 SUBMITTALS

A. Submit as specified in General Conditions.

B. Product data: As specified in Section 15050 - Common Work Results for Mechanical Equipment.

C. Shop drawings: As specified in Section 15050 - Common Work Results for Mechanical Equipment.

D. Calculations: As specified in Section 15050 - Common Work Results for Mechanical Equipment:
   1. Gate opening and closing thrust forces that will be transmitted to the support structure with operator at extreme positions and load.
   2. Torque required to open and close the gate, including maximum torque at any point along gate travel. Indicate thrust value and stem factor.
   3. Breakaway torque from seat. Indicate thrust value and stem factor.

E. Vendor operation and maintenance manuals: As specified in Section E01430 - Maintenance Manual Requirements.

F. Commissioning submittals:
   1. Provide Manufacturer’s Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.

G. Shop drawings:
   1. Layout and installation drawings for each gate size and type.
      a. Prior to submittal of shop drawings, determine actual size of opening to be covered and adjust gate dimensions accordingly.
   2. For coordination purposes, gate manufacturer shall supply calculations verifying the suitability of the selected motorized operator for the application. For each gate include:
      a. Open/close speed as specified in Section 13447 - Electric Actuators.
b. The maximum torque required for operation of the gate (including
breakaway from seat) with a safety factor of 1.4.
c. The torque supplied by the motorized operator scheduled in
Section 13447 - Electric Actuators for the operating speed specified in
Section 13447 - Electric Actuators.
d. The thrust output capacity of the motorized operator with the furnished
motor.

3. Wall thimbles design.
4. Submit calculations and design data substantiating conformance with the
Drawings and Specifications.
5. Gate opening and closing thrust forces that will be transmitted to the support
structure with operator at extreme positions and load.
6. Torque required to open and close the gate, including maximum torque at any
point along gate travel. Indicate thrust valve and stem factor.
7. Breakaway torque from seat. Indicate thrust valve and stem factor.

1.07 WARRANTY

A. Provide warranty as specified in General Conditions.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: One of the following or equal:
   1. Waterman Ind., Sentinel, Ill.

B. Operator anchor bolts and wall thimbles: Provided by manufacturer of slide gates.

2.02 MATERIALS

A. Stainless steel: ASTM A276, Type 316:
   1. Components or structural shapes which are welded: ASTM A276, Type 316L.
   2. All wetted and unwetted parts including all fasteners and hardware, except as
      specified in this Section, shall be stainless steel.

B. Ultra-high molecular weight polyethylene: ASTM D1248 and D4020.


D. Manganese bronze: ASTM B584, UNS Number C86500 or Alloy 432.

E. Silicon bronze: ASTM B584 UNS Number C87300.
2.03 COMPONENTS

A. Slide:
   1. Type 316L stainless steel.
   2. Rectangular or square.
   3. Fabricated with a flat plate reinforced with formed plates or structural members.

B. Frame:
   1. Construct gate frame of Type 316L stainless steel structural members or formed plate welded to form a rigid 1-piece frame.
   3. Adjustable ultra-high molecular weight polyethylene pressure pads.
   4. Flush bottom type unless otherwise indicated on the Drawings.
   5. Allow replacement of top, side, and bottom seals without removing the gate frame from concrete or wall thimble.
   6. Machine surfaces matching with thimble. Provide seal between gate frame and thimble that will meet leakage performance requirements.
   7. Embedded gates: Extend frame to provide access to pressure pad adjusting screws (For seal design alternatives A and B only).

C. Yoke for self-contained gates:
   1. Type 316L stainless steel.
   2. Extend guides and frame so that bottom of yoke is at least 12 inches above top of slide at full open position.
   3. Bolt or weld to frame.
   4. Provide mounting plate on top of yoke to mount operator.
   5. Design yoke to allow removal of gate slide.

D. Guides:
   1. Type 316L stainless steel with ultra-high molecular weight polyethylene insert in contact with gate.
   2. Minimum face width of 1 inch.
   3. Length: To support the slide fully in the open position.
   4. Anchor bolts shall not pass through the guides and seals.

E. Seals:
   1. Designed to achieve the specified leakage requirements.
   2. Sealing and sliding surfaces shall provide a low coefficient of friction with the surface of the slide.
   3. Field replaceable without removing gate from concrete or wall thimble.
   4. Anchor bolts shall not pass through the guides and seals.
   5. J-bulb seals are not acceptable.
   7. Bottom seal:
      a. Resilient EPDM, minimum durometer of 45.
b. Attached to the bottom of the slide or embedded in gate frame invert.

8. Side and top seals:
   a. Provide one of the seal design alternatives listed below.
   b. Seal design alternative A:
      1) UHMWPE fixed sealing surfaces that surround the clear opening.
      2) Held in place in the guide with Type 316 stainless steel fasteners.
      3) Seal compression shall be maintained by UHMWPE field adjustable pressure pads mounted to the slide with Type 316 stainless steel fasteners.
   c. Seal design alternative B:
      1) EPDM crown seal with UHMWPE bearing bars.
      2) Attached to the slide with Type 316 stainless steel fasteners.
      3) Crown seal shall be actuated by water pressure in either the seating or unseating direction.
      4) Primary contact with the slide shall be through the UHMWPE bearing bar. The neoprene shall not be solely relied upon for the contact seal.
      5) Seal compression may be maintained by UHMWPE field adjustable pressure pads mounted to the guide with Type 316 stainless steel fasteners.
   d. Seal design alternative C:
      1) UHMWPE self-adjusting type seals: Utilize a continuous compression cord to ensure contact between the seals and the slide.
      2) Side seals:
         a) Attach to frame using one of the following approaches:
            (1) Held in place between the front and back angles of the guide with Type 316 stainless steel bolts passing through the guide and seal along the length of the guide.
            (2) Held in place between front and back of a formed, 1 piece, rigid channel guide. Attach seals to frame using Type 316 stainless steel bolts.
         b) Design and installation shall provide access to and removal of the bolt to allow removal of the side seal without removing the gate from the concrete.
      3) Top Seal: UHMWPE self-adjusting type seal with double compression cord.

F. Stem:
   1. Type 316 stainless steel.
   2. Machine cut or rolled threads.
   3. Stem couplings:
      a. Silicon bronze or Type 316 stainless steel.
      b. Threaded and keyed to stem or threaded and bolted to stem.
   4. Stem guides:
      a. Type 316 stainless steel.
b. Split collar.
c. Adjustable in 2 directions.
d. Ultra-high molecular weight polyethylene bushing.

5. Provide manganese bronze stop collar on stem above actuator.

6. Drill and connect stem to slide structural sections with Type 316 stainless steel bolts.


8. Coordinate the selection of the gate stem configuration with the gate operator and operating speed:
   a. The selected gate stem configuration shall provide the most efficient combination of stem diameter/pitch/lead and keep the operating temperature at the stem nut to a minimum during operation.
   b. For motorized applications, if the proposed gate stem configuration would result in any deviation from the operating rise rate specified in Section 13447 - Electric Actuators, submit proposed deviation for approval by the Engineer.

G. Operating nut:
   1. Locate at operator level.

H. Gate operators: As specified in Section 13446 - Manual Actuators.

I. Bolts, nuts, and fittings: Type 316 stainless steel.

J. Anchor bolts:
   1. Type 316 stainless steel.

2.04 WALL THIMBLES

A. Provide wall thimbles for gates where scheduled and as indicated on the Drawings.

B. F-section of a depth equal to the thickness of the structure wall upon which the gate is mounted:
   1. Modify F-sections where required for F-section and pipe bell ring connections in a wall:
      a. Provide flange-by-mechanical joint or flange by push on joint wall thimble where ductile iron piping connects to the wall thimble. Ensure that joint wall thimble has sufficient embedment to resist pipe thrust.
      b. Provide flange-by-bell ring wall thimble insert where reinforced concrete piping connects to the wall thimble.

C. Fabricated Type 316L stainless steel of sufficient section to resist permanent distortion; minimum 3/8 inch thick plate.

D. Width of mounting flange of wall thimble: 1/2 inch wider than mounting flange of gate.
E. Fully machine front flange of thimble to a plane Drill and tap to match the drilling on the flange back gate seat.

F. Clearly mark top center of each thimble for installation.

G. Provide Type 316 stainless steel studs for attaching the gate frame.

H. Seal joint between thimble and gate watertight, in accordance with AWWA C561.

I. To permit entrapped air to escape as the thimble is being cast in concrete, drill holes in each entrapment zone formed by ribs, flanges, and water stops.

J. Provide annular weep ring to control seepage and resist thrust, where needed to anchor the pipe thrust restraint system:
   1. Continuously weld weep ring to outside of the wall thimble.
   2. Weep ring shall be minimum 1/4 inch thick and minimum 2 inches deep.

2.05 FINISHES

A. Stainless steel:
   1. Shot blast gates and wall thimbles after fabrication to remove weld splatter and to polish scratches.
   2. Clean the entire surface to produce an even color and sheen.

B. Operators, stands, and other accessory equipment: Surface preparation, factory prime, field prime, and finish coats as specified in Section 09960 - High-Performance Coatings.

2.06 FABRICATION

A. Shop assembly:
   1. Gates shall be factory assembled, adjusted, and tested.
   2. Mount all accessories and appurtenances including, but not limited to, motor operators and limit switches so that the complete system may be tested at the factory.

PART 3 EXECUTION

3.01 INSTALLATION

A. Mount thimbles and gates plumb in both vertical planes and level in horizontal plane.

B. Coat seating surfaces between frame and wall thimble with a waterproof plastic compound or provide EPDM gasket prior to tightening frame studs.
C. Adjust wedges or other parts of the gate to the point where it will not be possible to insert a 0.004 inch feeler gauge between the gate slide and the gate frame at any point:
   1. Securely lock wedges into position after adjustment.

D. Adjust limit switches in electric and hydraulic operators in accordance with manufacturer's instructions.

E. Face mounted gates:
   1. Where wall thimbles are not provided, mount gate to wall with anchor bolts and provide a 1-inch grout pad in accordance with manufacturer’s recommendations.

F. Embedded gates:
   1. Provide blockouts in sidewalls and channel bottom for installation of gates.
   2. After gate placement, adjustment, and alignment in accordance with manufacturer’s recommendations, grout frame with non-shrink grout.

3.02 COMMISSIONING

A. As specified in Section 01756 - Commissioning and this Section.

B. Manufacturer services:
   1. Provide certificates:
      a. Manufacturer’s Certificate of Installation and Functionality Compliance.
   2. Manufacturer’s Representative onsite requirements:
      a. Installation: 1 trip, 1 day minimum.
      b. Functional Testing: 1 trips, 1 day minimum each.
   3. Training:
      a. Maintenance: 2 hours per session, 2 sessions.
      b. Operation: 2 hours per session, 2 sessions.
   4. Process operational period:
      a. As required by Owner or Contractor.

C. Functional testing:
   1. Equipment:
      a. Test witnessing: Non-Witnessed.
      b. Leakage tests:
         1) Conduct in accordance with AWWA C 561. Comply with specified allowable leakage limits.
         2) After gate installation and checking, run gates through at least 2 full cycles from the closed position to full open position and back to the closed position.
3.03 SCHEDULE

A. The Slide Gate Schedule is included on the following page(s). The Slide Gate Schedule is not a take-off list. Contractor shall provide additional gates per specifications and as indicated on the Drawings.
### HEAVY-DUTY FABRICATED STAINLESS STEEL SLIDE GATE SCHEDULE

| Gate Tag Number or Mark Number | Drawing Number | Location | Opening Size W X H (inches)\(^{(7)}\) | Wall Opening Shape | Gate Opening Direction | Type of Closure\(^{(1)}\) | Gate Design Pressure\(^{(2)}\) | Seating (feet) | Unseating (feet) | Gate Mounting\(^{(3)}\) | Type of Frame\(^{(4)}\) | Stem Type\(^{(5)}\) | Type of Operator\(^{(6)}\) | Minimum Gate Travel (inch) |
|-------------------------------|----------------|----------|---------------------------------------|-------------------|-----------------------|--------------------------|-----------------------------|----------------|----------------|-------------------|----------------|----------------|----------------|----------------|----------------|
| GTE-41.1011                   | 41M01          | CCB (O.O.C. Diversion Gate) | 48X48 | Round | Up | STD | 15 | 10 | FM | NSC | RS | MO | 48 |
| GTE-41.1012                   | 41M01          | CCB (O.O.C. Isolation Gate) | 48X48 | Round | Up | STD | 15 | 10 | FM | NSC | RS | MO | 48 |
| GTE-45.1011                   | 01C16          | TEPS     | 48X48 | Round | Up | STD | 15 | 10 | FM | NSC | RS | FS | 48 |

Notes:

2. Gate design pressure applied at centerline of gate.
3. Mounting: FM = Face Mounted; EC = Inside Existing Channel; EMB = Embedded; SP = Spigot back; FWT = "F" Wall Thimble; EWT = "E" Wall Thimble; See Typical Details P716 and P717 for additional installation details.
4. Frame: SC = Self-Contained; NSC = Non-Self Contained; F = Flatback; FL = Flange back.
5. Stem: RS = Rising Stem; NRS = Non-Rising Stem.
6. Operator: CO = Hand crank operator with 2-inch AWWA nut for portable operator; HW = Handwheel; HC = Hand crank; MO = Motor Operator; MOD = Modulating Motor Operator; HO = Hydraulic Operator; MHO = Manual Hydraulic Operator (Hand Pump); BS = Bench Stand; FS = Floor Stand; IFS = Interconnect Floor Stand; PS = Pedestal Support.
7. Sizing of systems for gates set over cored holes shall take into account edge clearance outside the core's annular space.

END OF SECTION
SECTION 11312J

SUBMERSIBLE PROCESS LIQUID SUMP PUMPS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Submersible sump pumps, with a control panel and instrumentation.

1.02 REFERENCES

A. ASTM International (ASTM):

B. Hydraulic Institute (HI):
   1. 1.1-1.2 - Rotodynamic (Centrifugal) Pumps for Nomenclature and Definitions.
   2. 1.3 - Rotodynamic (Centrifugal) Pumps for Design and Application.
   3. 9.1-9.5 - Pumps - General Guidelines for Types, Application, Definitions, Sound Measurement, and Documentation.
   4. 11.6 - Submersible Pump Tests.

C. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).

1.03 DEFINITIONS

A. NEMA:
   1. Type 4X enclosures in accordance with NEMA 250.

B. Pump head (Total Dynamic Head, TDH), flow capacity, pump efficiency, net positive suction head available (NPSHa), and net positive suction head required (NPSHr): As defined in HI 1.1-1.2, 1.3, 9.1-9.5 and 11.6 and as modified in this Section.

C. Suction head: Gauge pressure available at pump intake flange or bell in feet of fluid above atmospheric; average when using multiple suction pressure taps, regardless of variation in individual taps.

1.04 SYSTEM DESCRIPTION

A. Components: Overhung impeller, close coupled, single stage, volute style, end suction submersible sewage pump. Other items include: Control panel, level control
instrumentation, discharge piping, necessary valves, gauges, taps, lifting eyes, stands, and other items as required for a complete and operational system.

B. Design requirements:
   1. Pump performance characteristics: As specified in the Pump Schedule, Pump Performance Characteristics:
      a. As specified in the Pump Schedule.
      b. Performance tolerances shall be the same as the test tolerances specified in Section 15958 - Mechanical Equipment Testing.
   4. Product requirements as specified in Section 01600 - Product Requirements and Section 15050 - Common Work Results for Mechanical Equipment.

1.05 SUBMITTALS

A. Submit as specified in General Conditions.

B. Calculations per Section 15050 - Common Work Results for Mechanical Equipment are not required for pumps specified in this Section.

1.06 QUALITY ASSURANCE

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

B. Provide pumps specified in this Section from same manufacturer.

C. Require pump manufacturer to furnish and coordinate pump, driver, and pump components as scheduled and to provide written installation and checkout requirements.

1.07 DELIVERY, STORAGE, AND HANDLING

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

1.08 PROJECT CONDITIONS

A. Environmental requirements: As specified in Section 01610 - Project Design Criteria.

1.09 SEQUENCING AND SCHEDULING

A. Coordinate work with restrictions specified in Section 01140 - Work Restrictions.

1.10 WARRANTY

A. As specified in Section 15050 - Common Work Results for Mechanical Equipment.
PART 2  PRODUCTS

2.01 MANUFACTURERS

A. Pumps: One of the following or approved equal:
   1. BJM Pumps,
   2. PACO (Pacific Pumping Co.)
   3. Hydromatic.

2.02 MATERIALS

A. Cast Iron: ASTM A48, Class 30 minimum.
B. Stainless Steel: ASTM A276 or equal.

2.03 PUMP CASING

A. Material: Cast iron.
B. Design working pressure: 1.5 times the shut off pressure.
C. Provide support legs on sump bottom and clearance for suction entrance.
D. The discharge connection shall be a 4-inch NPT vertical connection.

2.04 IMPELLERS

A. Material: Cast iron.
B. 2-vane; maximum enclosed; non-clogging; with pump-out vanes on backside; dynamically balanced; close coupled to motors.
C. Pump shall be designed to pump liquids containing solids up to 2.5-inch spherical diameter.
D. Method of securing to shafts: Threaded lock nut or similar connection.

2.05 PUMP SHAFTS

A. Material: 400 series stainless steel.

2.06 BEARINGS

A. Upper bearing:
   1. Single deep-groove ball bearing, lubricated by Chevron SRI grease rated for high temperature.
   2. Minimum bearing L10 life of 30,000 hours.
B. Lower bearing:
   1. Single deep-groove ball bearing, lubricated by Chevron SRI grease rated for high temperature.
   2. Minimum bearing L10 life of 30,000 hours.

2.07 SHAFT SEAL

A. Single mechanical seal.

B. Materials:
   1. Silicon carbide versus silicon carbide seal faces.
   2. Carbon versus ceramic seal faces.

C. Elastomer and hardware: Buna-N and 300 series stainless steel.

2.08 DRIVERS

A. Motors:
   1. Suitable for Class I, Division 2.
   2. NEMA B design.
   3. Air-filled submersible motor.
   4. Insulation: Class F.
   5. Power: 230/460 volt, 3 phase, 60 hertz.
   6. 1.15 service factor.
   7. Pumps shall be able to operate continuously without exceeding pumps service capacity when immersed in water up to 104 degrees Fahrenheit.
   8. Cable: Minimum length sump depth to the VCP, plus 15 feet, armored, waterproof cable securely attached to motors with watertight fittings.
   9. Moisture Protection System:
      a. The moisture protection system shall also detect water in the motor chamber.
   10. Thermal Protection System:
      a. Provide temperature detection in motor windings.
      b. The temperature detection system shall reset automatically.

2.09 ACCESSORIES

A. Chains or cables: Stainless steel; attached to balance point of pump; suitable for lifting pump from sump; long enough to extend from sump cover or grating:
   1. Hooks: Suitable to provide storage of chain or cable at top of sump.

2.10 FINISHES

A. Contractor to provide field coatings as specified in Section 09960 - High-Performance Coatings.
2.11 CONTROLS

A. General:
   1. Provide a vendor control panel at each installation for control of the pumps, except as indicated on the pump schedule.

B. Vendor control panel:
   2. Enclosure:
      a. As indicated in the pump schedule.
   3. Electrical components:
      a. Main circuit breaker:
         1) As specified in Section 16412 - Low Voltage Molded Case Circuit Breakers.
         2) Flange-mounted operator:
            a) Pad-lockable in the off position.
            3) Disconnects all power to the panel.
            4) Interlock with the panel door:
               a) Defeat mechanism.
      b. Motor starter for each pump:
         1) As specified in Section 16422 - Motor Starters.
      c. Control power transformer:
         1) Primary voltage: 230/460 VAC, 3 phase, 60 hertz.
         2) Secondary voltages:
            a) Control and status points to the facility SCADA system: 120 volt.
            b) Additional voltages as required by the application.
         3) Sized for all panel components plus 10 percent spare capacity.
         4) Primary and secondary fuses.
   4. Control components:
      a. Terminal strips:
         1) Provide terminal strips for landing all external wiring.
      b. Relays, timers, and other components as required providing the specified functionality and remote monitoring connections.
   5. Duplex operation:
      a. Front Panel Controls:
         1) HAND/OFF/AUTO switch.
         2) START pushbutton for each pump.
         3) STOP pushbutton for each pump.
         4) DUTY-STANDBY selector switch which will permit operator selection of either Pump Number 1 or Pump Number 2 as the lead pump during automatic operation.
         5) Momentary LOW-LEVEL OVERRIDE pushbutton.
         6) Running pilot light for each pump.
         7) Stopped pilot light for each pump.
8) Power pilot light.
9) Pump fault pilot light for each pump.
10) High-High level pilot light.
11) Low-Low level pilot light.
12) Local digital indicator of wetwell level.

b. Remote monitoring and control:
1) Provide dry relay contact outputs for the following:
   a) Pump Fault alarm: one for each pump.
   b) Pump Run status: each pump.
   c) High-High Level Alarm.
   d) Lo-Lo Level Alarm.
2) Provide 4-20 mA analog output for the following:
   a) Sump Level.

c. Operation:
1) Hand:
   a) The pump shall run when the START pushbutton is pressed.
   b) The pump shall stop when the STOP pushbutton is pressed.
   c) The LOW-level switch shall stop the pump.
   d) The LOW-level switch shall be overridden by the momentary
      LOW-LEVEL OVERRIDE pushbutton.
   e) Moisture and high temperature shall stop the pump.
2) Off: Pump shall stop operation:
   a) Placing the hand switch in the OFF position shall reset all alarm
      conditions.
3) Auto: The pump shall operate automatically in response to level
   transmitter signal:
   a) The lead pump shall start when the rising water level in the
      sump reaches an operator selected START level as indicated by
      the sump level transmitter.
   b) The lead pump shall stop when the falling water level in the
      sump reaches an operator selected STOP level as indicated by
      the sump level transmitter.
   c) If the lead pump fault alarm is activated the standby pump shall
      replace the lead pump.
   d) A high-high level shall cause the HIGH-HIGH-level float switch to
      activate. This will trigger a HIGH-HIGH-level alarm.

2.12 LEVEL SENSORS

A. Type: Submersible Pressure Transmitter:
1. Suitable for Class I, Division 2 for hazardous area or an intrinsically safe circuit
   per NEC.
2. As specified in Section 17407 - Pressure Measurement: Submersible.
3. Cable length: The length of the cable shall be equal to sump depth plus
   distance to included field mounted desiccant/termination box plus 5 feet.
B. Type: Float type level switch:
   1. Suitable for Class I, Division 2 for hazardous area or an intrinsically safe circuit per NEC.
   2. As specified in Section 17201 - Level Measurement: Switches.

2.13 SOURCE QUALITY CONTROL

A. Inspection and checkout: As specified in Sections 15050 - Common Work Results for Mechanical Equipment and 15958 - Mechanical Equipment Testing.

B. Equipment performance test: None required.

C. Vibration test: None required.

D. Noise test: None required.

E. Operational testing: As specified in Section 01756 - Commissioning.

F. Witnessing: Not required

2.14 SPARE PARTS AND SPECIAL TOOLS

A. Special tools: For each type or size of pump specified, provide 1 set of all special tools required for complete assembly or disassembly of the pump system components.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install submersible sump pumps as specified in Section 15050 - Common Work Results for Mechanical Equipment.

3.02 FIELD QUALITY CONTROL

3.03 INSPECTION AND CHECKOUT

A. As specified in Sections 15050 - Common Work Results for Mechanical Equipment and 15958 - Mechanical Equipment Testing.


C. Vibration test: None required.

D. Noise test: None required.

E. Operational testing: As specified in Section 01756 - Commissioning.
3.04 MANUFACTURER’S FIELD SERVICE

A. Start-up: Inspect system before initial start-up and certify that system has been correctly installed and prepared for start-up.

B. Training: As specified in Section 01756 - Commissioning.

3.05 PUMP SCHEDULE

A. Pump characteristics:

<table>
<thead>
<tr>
<th>Tag Numbers</th>
<th>PMP-24.1011</th>
<th>PMP-24.1012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Storm Drain Pump Station</td>
<td></td>
</tr>
<tr>
<td>Service</td>
<td>Stormwater</td>
<td></td>
</tr>
<tr>
<td>Pump Type</td>
<td>Submersible</td>
<td></td>
</tr>
<tr>
<td>Number of Pumps</td>
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<td></td>
</tr>
<tr>
<td>Capacity, gpm</td>
<td>250 gpm</td>
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</tr>
<tr>
<td>Total Dynamic Head (TDH), Feet</td>
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</tr>
<tr>
<td>Minimum Pump Efficiency</td>
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<td></td>
</tr>
<tr>
<td>Pass Minimum Sphere Size, Inch</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>Motor Horsepower</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Minimum Shutoff Head, feet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motor Voltage/Phases/Hertz</td>
<td>460/3/60</td>
<td></td>
</tr>
<tr>
<td>Motor Speed, revolutions per minute</td>
<td>1,750 rpm</td>
<td></td>
</tr>
<tr>
<td>VCP Required</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>VCP Enclosure</td>
<td>NEMA 4X Stainless Steel</td>
<td></td>
</tr>
</tbody>
</table>

END OF SECTION
SECTION 13115
YARD PIPING CATHODIC PROTECTION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Furnish, install, energize, and test yard piping cathodic protection facilities, including anodes, test stations, pipe flange insulation and associated wiring, hardware, materials, and miscellaneous items.

1.02 REFERENCES

A. American National Standards Institute (ANSI).

B. American Water Works Association (AWWA):

C. ASTM International (ASTM):
   1. D2103 - Standard Specification for Polyethylene Film and Sheeting.

D. NACE International (NACE):
   1. SP0169 - Control of External Corrosion on Underground or Submerged Metallic Piping Systems.
   2. SP0286 - Electrical Isolation of Cathodically Protected Pipes.

E. National Fire Protection Association (NFPA):
   1. 70 - National Electrical Code (NEC).

1.03 SYSTEM DESCRIPTION

A. Furnish and install all materials and equipment associated with anodes, corrosion monitoring stations, and insulated flanges as indicated on the Drawings and described in this Section:
   1. Any changes in design or method of installation of an item as specified and indicated on the Drawings must be accepted prior to installation.
   2. Coordinate installation of various components to coincide with other construction phases of project so installation of items specified in this Section can be completed in most efficient and expedient manner.
1.04  DEFINITIONS

A. Ferrous metal pipe: Any pipe made of steel or iron as well as containing steel or iron as a principal structural material, except reinforced concrete pipe and concrete cylinder pipe.

B. Lead, lead wire, joint bonds, cable, conductor, insulated copper conductor: The same as wire.

C. Electrically continuous pipe: A pipe which has a linear electrical resistance equal to or less than the sum of the resistance of the pipe plus the maximum allowable bond resistance for each joint as specified in this Section.

D. Electrical isolation: The condition of being electrically isolated from other metallic structures including, but not limited to pipe, reinforcement, and casing, and the environment as defined in NACE Standard SP0169.

1.05  SUBMITTALS

A. Submit as specified in General Conditions.

B. Product data:
   1. Include specific performance data, material descriptions, ratings, capacities, brand names, catalog or part numbers, general or specific types, and all other pertinent information and data. Shop drawings.

C. Calculations.

D. Quality control submittals:
   1. Qualifications of Contractor.
   2. Qualifications of corrosion engineer.

E. Operation and maintenance manuals:
   1. Test reports in booklet form tabulating all field tests and measurements performed, upon completion and testing of the installed system.

F. Commissioning submittals:
   1. Provide Manufacturer’s Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.

1.06  SYSTEM DESCRIPTION

A. Include, but not limited to, the following items:
   1. Anodes.
   2. Anode wires.
   3. Split bolt connectors.
   4. Electrical tape; high voltage rubber and vinyl.
5. Copper-sulfate reference electrodes.
6. Test station boxes and terminal boards.
7. Test station cables.
8. Cable warning tape.
9. Exothermic welding equipment.
10. Exothermic weld caps.
11. Coal tar mastic coating.
12. Pipe flange insulation materials.
13. Petrolatum tape wrap.

B. Ensure items furnished fit space available.
   1. Make necessary field measurements, including those for connections, and order such sizes and shapes of equipment in order that final installation suits true intent and meaning of Drawings and Specifications.

C. Where equipment requires different arrangement of connections from those indicated on the Drawings, install equipment to operate properly and in accordance with intent of Drawings and Specifications:
   1. Make all changes in Work required by different arrangement of connections as accepted by Engineer.

1.07 WARRANTY

A. Provide warranty as specified in General Conditions.

PART 2  PRODUCTS

2.01 ANODES

A. Magnesium anodes:
   1. Shall conform to following chemical composition:

<table>
<thead>
<tr>
<th>Element</th>
<th>MG-MN Alloy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum</td>
<td>0.010 maximum</td>
</tr>
<tr>
<td>Zinc</td>
<td>None</td>
</tr>
<tr>
<td>Manganese</td>
<td>0.50-1.30</td>
</tr>
<tr>
<td>Copper</td>
<td>0.02 maximum</td>
</tr>
<tr>
<td>Silicon</td>
<td>None</td>
</tr>
<tr>
<td>Iron</td>
<td>0.03 maximum</td>
</tr>
<tr>
<td>Nickel</td>
<td>0.001 maximum</td>
</tr>
<tr>
<td>Others</td>
<td>0.05 each</td>
</tr>
<tr>
<td>Magnesium</td>
<td>Balance</td>
</tr>
</tbody>
</table>
2. Shall be ribbon type as indicated on the Drawings:
   a. Shall be galvomag alloy, high current output type, extruded on a continuous steel wire core approximately 0.135-inch in diameter, with a cross section of 3/8 inch by 3/4 inch.

B. Anode wires:
   1. Connecting wire for magnesium ribbon anode shall be single conductor Number 8 American Wire Gauge stranded copper, of required length to reach each test station unspliced, in accordance with NFPA 70 Type HMWPE insulation and shall be field installed as indicated on the Drawings.

2.02 TEST STATIONS

A. Flush mount type: Each test station shall include the following:
   1. Housing boxes: 14-inch by 14-inch by 12-inch deep "PC" service box, open base type, complete with heavy-duty steel or cast iron traffic cover. Cover shall be imprinted with CP TEST:
      a. Manufacturers: The following or equal:
         1) Quazite Composilite Co., Model Number PC1212BG12.
   2. Test boxes: Cast aluminum suitable for mounting on 2-inch diameter rigid polyvinyl chloride conduit:
      a. Manufacturers: The following or equal:
      b. Cover: Cast aluminum with locking mechanism.
      c. Terminal block: 8 terminal type of glass-reinforced laminated plastic mounted inside test box, with nickel-plated brass terminal studs (non-turning), nuts, lockwashers, and shorting straps.
   3. Polyvinyl Chloride Conduit: Schedule 80, 2-inch diameter by 36-inch long.

B. Post mount type:
   1. Test boxes: Cast aluminum, suitable for mounting on 2-inch diameter rigid galvanized steel conduit:
      a. Manufacturers: One of the following or equal:
      b. Cover: Cast aluminum with locking mechanism.
      c. Terminal block: 8 terminal type of glass-reinforced laminated plastic mounted inside test box, with nickel-plated brass terminal studs (non-turning), nuts, lockwashers, and shorting straps.
   2. Wood post: Pressure treated cedar or redwood, 4-inch by 4-inch by 72-inch long.
   3. Conduit and fittings:
      a. Conduit: Rigid galvanized steel, 2-inch diameter.
      b. Conduit straps: Galvanized steel, 2 hole type, for 2-inch galvanized steel conduit.
      c. Conduit bushings: Plastic type, for use on 2-inch diameter galvanized steel conduit.
C. Test station cables:
   1. Number 10 American Wire Gauge stranded copper, single conductor, with XHHW insulation of color as indicated on the Drawings.

D. Test station cable terminals:
   1. Crimp type ring terminals, 1/4-inch diameter, tinned copper, of proper size to fit test station cables/wires, STA-CON.
   2. Manufacturers: The following or equal:
      a. Thomas and Betts Corp.

E. Cable warning tape:
   1. Polyolefin/polyethylene, standard weight and thickness in accordance with ASTM D2103, 3 inches wide, red, with imprint CAUTION - ELECTRIC LINE BURIED BELOW.
   2. Manufacturers: The following or equal:
      a. Terra Tape Reef Ind., Inc., extra stretch Number 540.

2.03 SPLIT BOLT CONNECTORS

A. Copper alloy, cold-forged type to minimum cold creep during prolonged or extended service.

B. Of proper size to accommodate cable sizes being connected.

C. Manufacturers: The following or equal:
   1. Burndy Co. of Norwalk.

2.04 ELECTRICAL TAPE

A. High voltage electrical tape:
   1. Manufacturers: The following or equal:
      a. 3M Electrical Products, Scotch Number 23.

B. Vinyl electrical tape:
   1. Manufacturers: The following or equal:
      a. 3M Electrical Products, Scotch Number 33+.

2.05 REFERENCE ELECTRODES

A. Copper-sulfate reference electrodes shall be "permanent" type, designed for direct burial, minimum 10 years service life:
   1. Shall be pre-packaged in low resistancy backfill formulated to retain moisture and maintain stability.
   2. Shall be equipped with Number 10 American Wire Gauge solid copper lead wire with black HMWPE insulation, of suitable length to reach appropriate test station without splicing.
3. Overall size shall be approximately 10-inch diameter by 24-inch long, and weighing approximately 25 pounds.
4. Manufacturers: The following or equal:
   a. Farwest Corrosion Control Co., Model SP-150.

2.06 EXOTHERMIC (THERMITE) WELD EQUIPMENT

A. General:
   1. Use exothermic (thermite) welding to attach cables to pipe being constructed under this contract.
   2. Equipment and weld material:
      a. Manufacturers: The following or equal:
         1) ERICO Products, Inc. (CADWELD).
   3. Interchanging of thermite weld materials from different manufacturers will not be allowed.
   4. Welder size and type, weld metal charge size and type, and associated items used shall be as determined and recommended by manufacturer in accordance with following parameters:
      a. Pipe material.
      b. Pipe size (diameter) and wall thickness.
      c. Cable size.
      d. Orientation of weld connection.

B. Equipment:
   1. Molds: Molds must be constructed of graphite. Ceramic "one-shot" molds will not be acceptable.
   2. Adaptor sleeves: Provide sleeves for all cable.
   3. Cartridges: As per manufacturer's specifications.

2.07 THERMITE WELD CAPS

A. Manufacturers: The following or equal:

2.08 COAL TAR MASTIC COATING

A. Manufacturers: The following or equal:
   1. Tapecoat Co., Tapecoat TC Mastic.

2.09 PIPE FLANGE INSULATION MATERIALS

A. Manufacturers: The following or equal:
   1. Central Plastics Co.

B. Flange gasket: Type "E" full flange face type, constructed of neoprene faced phenolic, of proper size, and ANSI pressure rating as required.
C. Insulating sleeves: Mylar, 1/32-inch thick, of proper size to fit flange bolts; 1 sleeve required for each bolt.

D. Insulating washers: G3 glass phenolic, 1/8-inch thick, of proper size to fit flange bolts. 2 washers required for each bolt:
   1. For insulated pipe flanges that will be buried, use stainless steel bolts and nuts instead of standard carbon steel parts.

2.10 PETROLATUM TAPE WRAP

A. In accordance with AWWA C217.

B. Plastic fiber felt type: Plastic fiber felt saturated with petrolatums, plasticizers, and corrosion inhibitors:
   1. Manufacturers: The following or equal:
      a. TRENTON Corp., TRENTON Number 1 Wax Tape.

C. Rock-shield type material:
   1. Manufacturers: The following or equal:
      a. TRENTON Corp., TRENTON Guard Wrap or poly-ply.

PART 3 EXECUTION

3.01 INSTALLATION

A. Magnesium ribbon anodes:
   1. Shall be placed on a level base of native soils and shall be backfilled with 6-inch lifts of native soil, with each lift compacted tightly:
      a. Native soil backfill shall be free of vegetation, clods, and debris of any kind; and shall contain rocks no larger than 2 inches in diameter.
      b. Care shall be taken during installation, backfilling and compaction procedures to ensure no damage is caused to magnesium ribbon anodes.
   2. Cable-to-anode connections:
      a. Shall be made as indicated on the Drawings using copper alloy split bolt connectors of proper size to accommodate steel wire core of magnesium ribbon anode and Number 8 American Wire Gauge copper cable:
         1) Only enough magnesium anode material shall be removed from end to expose sufficient steel wire core for installation of split bolt connectors.
         2) Before installing split bolt connectors and making connections, exposed anode core wire shall be cleaned by lightly filing with a good quality fine tooth steel file:
            a) Emery cloth, sand paper, or other such materials shall not be used.
3) Split bolt connectors shall be installed using proper torque to make cable-to-anode connections, taking care to ensure no bending, kinking, or other damage occurs to cable or to steel wire anode core.

4) After split bolt connectors have been installed, entire connection shall be covered with a minimum 1/2-inch thickness of high voltage rubber insulating tape, wrapped in a spiral manner using half-lapped wrappings.

5) High voltage rubber tape wrapping shall extend for a minimum distance of 4 inches beyond cable-to-anode connection area in both directions, over insulation on the Number 8 American Wire Gauge cable and over magnesium anode material on the ribbon anode.

6) High voltage rubber tape wrapping shall be covered with a vinyl electrical tape wrapping of not less than 2 layers applied in a spiral half-lapped manner.

7) Vinyl electrical tape wrapping shall extend at least 1 inch beyond high voltage rubber tape wrapping in both directions.

b. Cable-to-anode connections shall be made after magnesium ribbon anode lengths have been installed, but before final backfilling and compaction of native soils over ribbon anodes is begun:

1) Cable-to-anode connections shall be backfilled with magnesium ribbon anodes, with care taken so as not to stretch or damage connections in any way.

2) The Number 8 American Wire Gauge cables from cable-to-anode connections shall be extended aboveground for installation into test stations.

3) Sufficient cable shall be used at each location to make installation from anode connections into test stations in 1 continuous length, with sufficient slack provided to minimize stress on cables during backfilling.

4) No splicing of anode cables shall be allowed.

B. Test stations:

1. General:
   a. Install test stations along pipe systems at locations as indicated on the Drawings:
      1) Drawings indicate general locations of test stations. In conjunction with Engineer, determine exact location of each test station based on actual site conditions and other circumstances which may be involved.
      2) Position each test station in protected, accessible locations as accepted by Engineer.
      3) Connect test station cables to pipe in accordance with Drawings and this Section.
      4) Connect test station cables inside test boxes using crimp-type ring terminals of size required and type specified.
5) Install underground cable runs less than 24 inches below finish grade in conduit.

2. Flush mount test stations:
   a. Install flush mount test stations at locations indicated on the Drawings.
   b. Install 14-inch by 14-inch by 12-inch service boxes even with finish grade, and bed in pea gravel:
      1) Pea gravel shall be a minimum of 6-inch deep.
      2) Pea gravel inside service box shall be no higher than 2 inches above bottom of box.
   c. The 2-inch diameter polyvinyl chloride conduit installed inside box shall extend no more than 3 inches above bottom of box:
      1) Top of the polyvinyl chloride conduit shall be trimmed smooth and flat.
   d. Test station terminal box or boxes (as required), complete with terminal boards, hardware, and cover(s), shall be laid inside service boxes but shall not be installed on the polyvinyl chloride conduit.
   e. Test cables terminated inside test station terminal boxes shall each have a sufficient coil of slack cable to allow test station terminal boxes to be lifted out of service boxes for a minimum distance of 18 inches.

C. Exothermic welding procedures:
   1. Connection of copper cables to steel surfaces shall be made by exothermic (thermite) weld method:
      a. Observe proper safety precautions, welding procedures, exothermic weld material selection, and surface preparation as recommended by welding equipment manufacturer.
      b. Ensure pipe is of sufficient thickness so that exothermic weld process will not damage integrity of pipe or fitting wall or protective lining.
   2. Before each connection is made, clean surface to bare metal by making a minimum 2-inch by 2-inch window in any previously applied pipe coating, and then file or grind surface to produce a bright metal finish:
      a. Accomplish grinding with vitrified type grinding wheel:
         1) Use of resin, rubber, or shellac impregnated type grinding wheels will not be acceptable.
      b. Prepared metal surface shall be dry.
   3. Install copper sleeves on ends of cables before welding to metal surface:
      a. Remove only sufficient insulation from cables to allow installation of copper sleeves and proper placement in mold.
      b. Perform thermite welding in strict accordance with manufacturer's written instructions.
      c. After weld connection has cooled, remove all slag by wire brushing, and physically test cable connection by several sharp direct blows with a hammer:
         1) Remove and replace any defective connections.
d. After weld is completed, trim cable insulation smooth prior to coating. Clean welds and surrounding area free of slag and dirt prior to coating.
e. Completed weld connections shall be inspected and accepted by Engineer before final coating of welds and backfilling of pipe.

4. After cleaning and testing of each weld, install prefabricated thermite weld cap over weld connection area:
   a. Use proper weld cap primer for installation of weld caps, in strict accordance with manufacturer's specifications and recommendations.
   b. Following installation of thermite weld cap, coat entire cable connection weld area with 2 coats of coal tar mastic, in accordance with manufacturer's specifications and instructions:
      1) Allow sufficient time between coating applications to provide proper curing of coating.
      2) Apply sufficient coating to ensure that any exposed metal, including copper cable, is completely covered.

5. Completed cable connections shall be inspected and accepted by Engineer prior to backfilling of pipe.

D. Reference electrodes:
   1. Install at locations and in manner as indicated on the Drawings:
      a. Place at a maximum distance of 12 inches from pipe.
      b. Do not handle or lower reference electrodes by cable.
      c. Remove plastic or paper bags used for protection during shipping from reference electrodes before installation.
      d. Place native soil free of rocks and clods around reference electrode in 6-inch lifts and well compacted. When compacted soil has been placed on top of reference electrode, pour water into hole to saturate reference electrode, backfill, and surrounding soil.
      e. Continue backfilling with soil compacted in 6-inch lifts to the ground surface.
      f. Damage caused to reference electrodes or components will require replacement of entire assembly.

E. Cable installation:
   1. Install buried cables straight without kinks, with a minimum cover of 24 inches:
      a. Install cables with less than 24 inches of ground cover in conduit, as accepted by Engineer.
      b. Bottom of cable trench shall be free from stones, roots, or other materials which might damage insulation of cables.
      c. Install cables in conduit from top of pipe to test boxes where backfill may damage cables.
2. Cable shall be continuous in length and free of splices unless otherwise or accepted by Engineer:
   a. Use care during installation to avoid abrasions, punctures, cuts, or any other damage to cable insulation.
   b. Repair or replace any cable with damage to insulation.

F. Cable warning tape:
   1. All buried cables shall have warning tape placed 10 inches to 12 inches above entire lengths during backfilling operations:
      a. Bring warning tape to within 6 inches of finish grade.

G. Pipe flange insulation:
   1. Provide pipe flanges with electrical insulating materials (insulating flange kits) at locations indicated on the Drawings to provide electrical isolation of specified sections of pipe from other sections:
      a. Install all piping and piping components free of foreign materials and construction debris.
      b. Gasket seating surface shall be free from tool marks, scratches, pits, deposits, or gouges greater than regular machining marks in a circular pattern:
         1) If seating surface is damaged, machine within tolerance of flange specification.
         2) If re-machining is not possible, replace flange.
   2. Install insulating flange kit materials in strict accordance with manufacturer's instructions and recommendations:
      a. Align pipe flanges for installation of bolts flange gasket, insulating sleeves and washers, and metallic washers and bolts.
      b. Use lubricant or anti-seizing compound, as recommended by insulating flange kit manufacturer, on bolt and nut threads to provide proper engagement and facing of parts.
      c. Install bolts and associated parts finger-tighten in sequence as outlined in manufacturer's installation instructions.
      d. After installation is completed, torque nuts and bolts in proper sequence as directed by manufacturer's installation instructions.
   3. Following installation of each insulating flange kit, conduct electrical resistance testing to ensure that all flange insulation components have been properly installed and that proper electrical insulation has been achieved:
      a. Measure electrical resistance across each individual stud (bolt) in flange, in accordance with NACE SP0286:
         1) Accomplish testing in presence of Engineer, with pipe empty and one side of pipe flange undergrounded at time of testing.
         2) Accomplish testing with an ohmmeter acceptable to Engineer.
         3) Minimum acceptable resistance across each individual bolt shall be 50,000 ohms.
b. Remove and replace any defective insulating parts with new parts:
   1) Following removal and replacement of defective parts, repeat resistance tests with all flange bolts.

3.02 PIPE CONTINUITY TESTING

A. After backfilling of pipe and anodes is complete, but before anodes are connected to pipe, conduct electrical continuity testing on each section of pipe system between insulated flanges to ensure pipe sections are electrically continuous and isolated from other sections and other structures.

B. Testing procedure:
   1. Conduct continuity tests by measuring response of buried piping potential to application of simulated cathodic protection test current in following manner:
      a. An auxiliary (temporary) ground shall be installed at a minimum distance of 10 feet from pipe near or adjacent to a cathodic protection test station.
      b. Auxiliary ground shall be connected to positive direct current output terminal of a portable cathodic protection rectifier unit or "steady source" direct current power supply, as pre-approved by Engineer.
      c. Connect negative direct current output terminal of rectifier or direct current power supply to pipe by means of test cables in cathodic protection test station.
      d. Adjust direct current output of rectifier or power supply to provide a pipe potential no more negative than minus 2.00 volts with respect to a standard copper-sulfate reference electrode in contact with earth directly over pipe at test station location.
      e. Record direct current voltage and current output of rectifier or power supply, along with pipe-to-copper-sulfate reference electrode potential measured at or near the auxiliary ground.
      f. With direct current test current turned on and off on a cycling basis (by means of a current interrupter installed in test circuit), "on" and "off" pipe-to-copper-sulfate reference electrode potential measurements shall be taken at 10-foot intervals in both directions away from auxiliary ground and power source.
      g. All measurements shall be recorded.
      h. Continuity testing shall be accomplished in presence of Engineer.
   2. If, at any location along a section of pipe, pipe-to-copper-sulfate reference electrode potential is changed in a positive direction with direct current test current on, a break in electrical continuity of pipe is indicated:
      a. Such "positive" changes in pipe-to-copper-sulfate reference electrode potential measurements will require excavation and repair of defective insulated flanges.
      b. Required excavation work and repairs shall be accomplished by Contractor at no additional cost to Owner.
c. Following repair work and backfilling of pipe, electrical continuity tests shall again be run to ensure repairs have been effective and pipe section is electrically continuous as specified.

d. Repair work and electrical continuity retesting shall be done in presence of Engineer.

3.03 CATHODIC PROTECTION SYSTEM TESTING

A. Baseline potential measurements:
   1. After backfilling of pipe and anodes is complete, but before anodes are connected to pipes, static potential measurements of pipes shall be made.
   2. Baseline potential measurements of pipe shall be made at each test station installed under this Contract:
      a. With respect to buried reference electrodes at each location.
      b. With respect to a portable copper-sulfate reference electrode reference electrode in contact with earth directly over pipe at each test station.
      c. With respect to a portable copper-sulfate reference electrode over pipe at 10-foot intervals along pipe section.
      d. Utilizing a high resistance, direct current voltmeter having an internal resistance (sensitivity) of not less than 100,000 ohms per volt.
   3. All baseline potential measurements taken shall be recorded, including values obtained, date, time, and location.

B. Energized potential measurements:
   1. Upon completion of pipe-to-soil baseline potential measurements, connect anode cables to pipe cables in test stations.
   2. As anodes are connected to pipe, measure current output from anodes through test station shunt with an approved high resistance voltmeter. Record values obtained, with date, time, and location.
   3. With entire cathodic protection system connected, energized pipe-to-soil potential measurements shall be made with respect to a portable copper-sulfate and with respect to the buried permanent reference electrodes.
   4. Locations of measurements shall be identical to locations used for baseline potentials:
      a. Record values obtained, along with date, time, and locations of measurements.

C. Criteria of protection:
   1. Criteria for determining adequacy of cathodic protection on buried pipe shall be in accordace with NACE SP0169 and shall be selected by Corrosion Engineer as applicable.

D. Inspection:
   1. Upon completion of all work, corrosion control facilities installed under this Contract will be inspected and tested by Engineer to ensure complete conformance with Contract Documents.
2. Any unapproved deviations or changes from design made by Contractor during installation of facilities shall be corrected.
3. Any or all deficiencies in facilities found through final testing shall be corrected to meet requirements of Contract Documents.

3.04 COMMISSIONING

A. As specified in Section 01756 - Commissioning and this Section.

B. Manufacturer services:
   1. Provide certificates:
      a. Manufacturer’s Certificate of Installation and Functionality Compliance.
   2. Manufacturer’s Representative onsite requirements:
      a. Installation: 1 trip, 3 day minimum.
      b. Functional Testing: 2 trips, 2 day minimum each.
   3. Training:
      a. Maintenance: 4 hours per session, 2 sessions.
      b. Operation: 2 hours per session, 2 sessions.
   4. Process operational period:
      a. As required by Owner or Contractor.

END OF SECTION
SECTION 13446

MANUAL ACTUATORS

PART 1     GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Valve and Gate Operators.
   2. Handwheel Operators.
   3. Floor Stands.
   4. Accessory Equipment and Floor Boxes.

B. Inclusion of a specific manufacturer’s name in the Specifications does not mean that the specific manufacturer’s standard product will be acceptable. Specified manufacturer’s or other manufacturer’s standard product shall be modified as required to meet the Specifications.

1.02 REFERENCES

A. Aluminum Association (AA):
   1. DAF-45 - Designation System for Aluminum Finishes.
   2. AA-M12-C22-A41 - Designation for Aluminum Finishes.

B. American Water Works Association (AWWA).

1.03 SUBMITTALS

A. Shop Drawings.

1.04 QUALITY ASSURANCE

A. Provide valve operators integral with valve or gate, except for valve operators using T-wrenches or keys, and portable operators intended to operate more than one valve.

B. Provide similar operators by one manufacturer.

C. Provide gates and hand operating lifts by one manufacturer.

D. Provide hydraulic gate lifts by one manufacturer.

E. Provide hydraulic valve operators and motorized operators by one manufacturer.
1.05 MAINTENANCE

A. Contractor, inspector, and District’s maintenance representative shall inventory and account for all tools and spare parts delivered to the site. Each party shall sign a turnover agreement. District will then take possession and responsibility for items.

1.06 VALVE AND GATE OPERATORS

A. Valve actuators:
   1. Manual actuators:
      a. Material: Type 316 stainless steel.
      b. Design: Hand lever.
      c. Spring release handle: 12-inch.
      d. Notch plate: 10 position.
      e. Secure with mounting bolts.
      f. Locking device so that valve can be locked in any position with a wing nut.

B. Stem covers:
   1. Aluminum pipe; threaded cap on top; bolted aluminum flange on bottom; 1-inch by 12-inch slots cut at 18 inches on center in front and back of pipe; capable of covering threaded portion of greased stems that project above operators when gates or valves are opened or closed.

C. Stem Cover Flanges, Pipes, and Caps:
   1. Etched and anodized to produce chemical finishes in accordance with AA-M12-C22-A41, medium matte finish, and clear anodic coating, as described in AA Publication 45, after fabrication.

D. Gate Stem Covers: Concentric with stem.

E. Position Indicators:
   1. Tail rods on hydraulic cylinders, or dial indicators with clear full-open and closed position indicators, calibrated in number of turns or percentage of opening.

F. Manual Operator Size:
   1. Sized to deliver maximum force required under most severe specified operating condition, including static and dynamic forces, seat and wedge friction, and seating and unseating forces with safety factor of 5, unless otherwise specified.

G. Operator Size: Capable of supporting weight of suspended shafting unless carried by bottom thrust bearings; shaft guides with wall mounting brackets.

H. Provisions for Alternate Operation: Where specified or indicated on the Drawings, position and equip crank or handwheel operated geared valve operators or lifts for alternate operation with tripod mounted portable gate operators.
I. Operation: Counterclockwise to open with suitable and adequate stops, capable of resisting at least twice normal operating force to prevent overrun of valve or gate in open or closed position.

J. Open Direction Indicator: Cast arrow and legend indicating direction to rotate operator on handwheel, chain wheel rim, crank, or other prominent place.

K. Buried Operator Housing: Oil and watertight, specifically designed for buried service, factory packed with suitable grease, completely enclosed space between operator housing and valve body so that no moving parts are exposed to soil; provide operators with 2-inch square AWWA operating nut.

L. Worm Gear Operators: Provide gearing on worm gear operators that is self-locking with gear ratio such that torque in excess of 160 foot-pounds will not need to be applied to operate valve at most adverse conditions for which valve is designed.

M. Traveling Nut Operators: Capable of requiring maximum 100 foot-pounds of torque when operating valve under most adverse condition; limit stops on input shaft of manual operators for fully open and closed positions; non-moving vertical axis of operating nut when opening or closing valve.

### 1.07 HANDWHEEL OPERATORS

A. Manufacturers: One of the following or equal:
   1. Rodney Hunt Co.
   2. Waterman Industries, Inc.

B. Coating: Handwheel as specified in Section 09960 - High-Performance Coatings.

C. Mounting: Floor stand or bench stand. Unless otherwise indicated on the Drawings position operator 36 inches (nominal) above top of walkway surface.

D. Bearings above and below finished threaded bronze operating nut: Ball or roller.

E. Wheel Diameter: Minimum 24 inches.

F. Indicator: Counterclockwise opening with arrow, and word OPEN cast on top of handwheel indicating direction for opening.

G. Pull to operate: Maximum 40 pounds pull at most adverse design condition.

H. Stem travel limiting device: Setscrew locked stop nuts above and below lift nut.

I. Grease fittings: Suitable for lubrication of bearings.

### 1.08 HAND-CRANKED GEARED OPERATORS

A. Type: Single removable crank; fully enclosed.
B. Mounting: Floor and Bench Stand. Unless otherwise indicated on the Drawings position operator 36 inches (nominal) above top of walkway surface.

C. Operating Nut: When scheduled for portable operators.

D. Geared Lifts: Two-speed with minimum ratio of 4 to 1.

E. Teeth on Gears, Spur Pinions, Bevel Gears, and Bevel Pinions: Cut.

F. Lift Nuts: Cast manganese bronze.


H. Bearings above and below Flange on Lift Nuts: Ball or roller; capable of taking thrust developed by opening and closing of gates under maximum operating head; with bronze sleeve bearings and sufficient grease fittings for lubrication of moving parts, including bearings and gears.

I. Crank Rotation Indicator: Cast arrow with word OPEN in prominent location readily visible indicating correct rotation of crank to open gate.

J. Hand Cranks: 15 inch radius; requiring maximum 25 pounds pull to operate gate at maximum operating head; with:
   1. Revolving brass sleeves.
   2. Gears, spur pinions, bevel gears, and bevel pinions with cut teeth.
   3. Cast manganese bronze lift nuts.
   4. Cast-iron lift parts with smooth exterior surfaces.

K. Indicator: Dial position type mounted on gear operator; enclosed in cast-iron or aluminum housing with clear plastic cover; marked with fully open, 3/4, 1/2, 1/4, and closed positions.

1.09 FLOOR STAND

A. Manufacturers: One of the following or equal:
   1. Rodney Hunt Company.
   2. Waterman Ind.
   3. Whipps, Inc.

B. Floor Stand Assemblies: Heavy-duty cast-iron, suitable for mounting specified operator.

1.10 ACCESSORY EQUIPMENT

A. Wall Brackets or Haunches: As indicated on the Drawings.

B. Stems: Stainless steel; sized to match output of operator; minimum gate or valve operating stem diameter; maximum 200 slenderness ratio.
C. Stem Couplings: Stainless steel; internally threaded to match stem; lockable to stem by set screw; with cold rolled double lead threads to eliminate excess operator stress. Cut stems are not allowed.

D. Stem Guides: Cast-iron with silicon bronze bushing; maximum 200 slenderness ratio; capable of being mounted with wall bracket; adjustable in two directions.

E. Wall Brackets: Cast-iron, capable of withstanding output of operator, adjustable in two directions.

F. Stem Stuffing Boxes: Cast-iron, with adjustable gland and packing.

G. Fasteners and Anchor Bolts: 316 stainless steel.

H. Geared Valve Operators: Provided with cut gears, either spur or worm; sized to operate valves at most adverse design condition; with maximum 40-pound pull at handwheel or chain wheel rim.

I. Geared Valve Traveling Nut Operators: Acceptable only where specified or indicated on the Drawings.


PART 2 EXECUTION

2.01 INSTALLATION

A. Install floor boxes in concrete floor with lid flush with floor.

B. After installation of gate and stem covers, mark stem covers at point where top of stems are at full-open position and at closed position.

C. Attach floor stand to structure with anchor bolts.

D. Install stem stuffing boxes where operating stems pass through intermediate concrete floor slabs.

E. Valve operators are to be installed where specified and designated on the Contract Drawings. The Contractor is responsible for installation of the correct valve operator as specified to provide a complete piping system as specified.

2.02 SCHEDULES

A. Geared Operators: Provide geared operators for following valves:
   1. Butterfly valves larger than 6 inches, nominal size, on liquid service.
   2. Butterfly valves larger than 10 inches, nominal size, on gas and air service.
B. Handwheel Operators: Provide handwheel operators for valves mounted 6 feet or less above floors.

C. Chain Wheel Operators: Provide chain wheel operators for valves mounted more than 6 feet to centerline above floors.

PART 3 EXECUTION
Not Used.

END OF SECTION
SECTION 13447
ELECTRIC ACTUATORS

PART 1 GENERAL

1.01 SUMMARY

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

1.02 REFERENCES

A. American Water Works Association (AWWA):

B. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).

1.03 DEFINITIONS

A. NEMA:
   1. Type 4X enclosure in accordance with NEMA 250.

1.04 SUBMITTALS

A. Submit as specified in General Conditions and Section 15050 - Common Work Results for Mechanical Equipment.

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

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

D. Shop drawings:
   1. Wiring diagrams:
      a. Include all options and expansion cards furnished with each actuator.
   2. Dimensioned drawings of each valve and actuator combination.
   3. Dimensioned drawings of each valve gearbox.
   4. Electric motor data.

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

F. Provide draft vendor operation and maintenance manual as specified in Section E01430 - Maintenance Manual Requirements:
   1. Include a list of all configurable parameters, and the final values for each.
   2. Include a troubleshooting chart covering the complete valve and controls/electrical power systems, showing description of trouble, probable cause, and suggested remedy.

G. Commissioning submittals:
   1. Provide Manufacturer’s Certificate of Source Testing as specified in Section 01756 - Commissioning:
      a. Affidavit in accordance with AWWA C542.
   2. Provide Manufacturer’s Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.

H. Project closeout documents:

1.05 WARRANTY

A. Provide warranty as specified in General Conditions.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers for lines 4 inch and larger:
   1. One of following no equal:
      a. EIM.
      b. Auma:
         1) SA/GK (multi-turn) with Aumatic AC controls.
2.02 CHARACTERISTICS FOR ACTUATORS ON LINES 4 INCHES AND LARGER

A. Provide actuators complete and operable with all components and accessories required for operation.

B. Power supply:
   1. Voltage and phases as indicated in the Motorized Actuator Schedule.
   2. Valve or gate motion independent of power supply phase rotation.
   3. Provide an internal backup power source or mechanical indicator to maintain settings and track valve position when main power is off.
   4. The actuators shall incorporate all major components such as the motor, starter, local controls, terminals, etc. housed within a self-contained, sealed enclosure.

C. Size actuator to move gates or valves from full open to closed position within the time indicated in the Motorized Actuator Schedule:
   1. If an operating time is not indicated on the Motorized Actuator Schedule, size the actuator to move gates or valves at minimum 12 inches per minute under maximum load. Measure rate of closure for valves at maximum diameter of disc, plug, or ball.
   2. Size actuators so that gear boxes are not required where possible.

D. Control interface:
   1. Configuration:
      a. Provide a non-intrusive, non-contacting interface for configuring all input and output settings, control values, ranges, torque switch settings, valve positions switch settings, and options:
         1) Configurable from a handheld configuring tool or input devices on the actuator.
      2. Local interface, integral to actuator:
         a. Non-intrusive, non-contacting selector switches:
            1) LOCAL-STOP-REMOTE:
               a) Motor actuator operation is prevented with the switch in STOP.
            2) OPEN-CLOSE:
               a) Controls the valve when LOCAL-STOP-REMOTE is in LOCAL.
               b) Spring return to center.
               c) Configurable between maintained (actuator runs until end of travel, high torque, or a LOCAL-STOP-REMOTE is switched to STOP) and momentary (actuator stops when lever is released).
            b. Local display:
               1) Valve fully open and fully closed indicators.
               2) Numerical display showing actual valve or gate position in percent of travel.
      3. Control inputs:
         a. Capable of using 120 VAC inputs.
         b. Controls the valve when LOCAL-STOP-REMOTE is in REMOTE.
c. Isolated inputs capable of operating from external control voltage source or internal power supply:
   1) Furnish 120 VAC or 24 VDC control power supplies within the actuator.
d. Provide the following inputs:
   1) OPEN.
   2) CLOSE.
   3) STOP.
e. OPEN and CLOSE inputs configurable between maintained (actuator runs until end of travel, high torque, or a STOP input) and momentary (actuator stops when command is removed).

4. Status outputs:
   a. Monitor relay output: Dry contact, normally closed, opens when actuator is not in REMOTE or in the event of any internal fault or alarm condition.
   b. Dry contact outputs configured for the functions indicated on the Drawings. Provide the following outputs for all actuators:
      1) Fully closed.
      2) Fully open.
      3) LOCAL-STOP-REMOTE in REMOTE position.
   c. All output contacts rated for 5 amps, 120 VAC.

E. Features:
   1. Time delay on reversal: Incorporate time delay between stopping actuator and starting in opposite direction to limit excessive current, torque, and heating from instantaneous reversal.

2. Data logging:
   a. Store diagnostic data and reference data:
      1) Store reference data (recorded during commissioning) and data from last operation.
   3. Provide display of logged data on the actuator, or provisions to download to a personal computer.

F. Materials:
   1. Construct motorized actuators of materials suitable for the environment in which the valve or gate is to be installed.

G. Components:
   1. Motors.
   2. Specifically designed for valve actuator service with high starting torque, totally enclosed non-ventilated construction.
3. Torque ratings equal to or greater than that required for valve seating and dynamic torques with a 25 percent factor of safety:
   a. Design requirements for rubber-seated AWWA butterfly valves:
      1) Design actuators for maximum gate or valve operating torque, in accordance with and using safety factors required in AWWA C504 and AWWA C542:
         a) Valve actuator torque requirement for open-close service: Not less than the required valve-seating and dynamic torques under design operating conditions in accordance with AWWA C504.
         b) Valve actuator torque requirement for modulating service: Not less than twice the required valve dynamic torque under design operating conditions in accordance with AWWA C504.
   b. Design requirements for slide gates, gate valves, knife gate valves, globe valves, and diaphragm valves:
      1) Design valves and actuators for maximum operating torque, in accordance with and using safety factors required in AWWA C542.
      2) Design for the maximum torque and thrust running load over the full cycle.
      3) Maximum torque or thrust rating: The actuator stall torque or maximum thrust output shall not exceed the torque or thrust capability of the valve or gate, as determined by the valve or gate manufacturer.

4. Capable of being removed and replaced without draining the actuator gear case.

5. Motor bearings shall be amply proportioned of the anti-friction type and permanently lubricated.

6. Rated for operating under the following conditions without exceeding temperature limits with ambient temperature of 40 degrees Celsius:
   a. Continuous operation for 15 minutes or twice the open-to-close operating time (whichever is greater) at normal operating torque or 33 percent of maximum torque (whichever is greater).
   b. 60 starts per hour for open/close service or 1,200 starts per hour for modulating service.

7. Provide the following motor protection features:
   a. Jammed valve (no valve motion detected through a time delay).
   b. High motor temperature (sensed by an embedded thermostats).
   c. High torque.
   d. Single phasing protection.

H. Enclosures:
   1. Actuator housing ratings as indicated in the Motorized Actuator Schedule.
   2. Stainless steel external fasteners.
   3. Provide o-ring seals for each of the following areas:
      a. Between the terminal compartment and the internal electrical elements.
b. Between the mechanical and electrical portions to protect from the ingress of oil, and to protect the mechanical components of oil from dust and moisture when the electrical terminal is open.

4. Provide the following minimum enclosure ratings:
   a. NEMA Type 4X enclosure for general applications.

I. Position sensing:
   1. Electronic and adjustable using a solid-state encoder wheel:
      a. Mechanical limit switches and potentiometers are not acceptable.
   2. Capable of retaining position and monitoring valve or gate motion when valve is manually actuated and when main power is not present.
   3. Valve range and position switch outputs field adjustable.

J. Torque sensing:
   1. Torque shutdown setting: 40 percent to 100 percent rated torque:
      a. Adjustable in 1 percent increments.
   2. Capable of interrupting control circuit during both opening and closing and when valve torque overload occurs.
   3. Electrical or electronic torque sensing:
      a. Extrapolating torque from mechanically measured motor speed is not acceptable due to response time.
   4. Independent of variations in frequency, voltage, or temperature.
   5. The actuator shall store actual operational torque curves for retrieval by plant maintenance staff.
   6. Provide a temporary inhibit of the torque sensing system during unseating or during starting in mid-travel against high inertia loads.
   7. Provide visible verification of torque switch status without any housing disassembly.

K. Manual actuators:
   1. Hand wheel for manual operation:
      a. Maximum 80-pound pull on rim when operating gate or valve under maximum load.
      b. Provide pull chain when motorized actuator is located more than 6 feet above floor surface:
         1) Chain shall be of sufficient length to reach approximately 4 feet above the operating level.
         2) Where the chain obstructs an aisle or walkway, provide holdback or other means to ensure chain does not create a nuisance or hazard to operating personnel.
   2. Declutch lever: Padlockable, capable of mechanically disengaging motor and related gearing and freeing hand wheel for manual operation.

L. Gearing: Hardened alloy steel spur or helical gears and self-locking, alloy bronze worm gear set:
   1. Accurately cut to ensure minimum backlash.
M. Bearings:
   1. Anti-friction bearing with caged balls or rollers throughout.
   2. Sealed-for-life type thrust bearings housed in a separate thrust base.

N. Drive bushing:
   1. Easily detachable for machining to suit the valve stem or gearbox input shaft.
   2. Positioned in a detachable base of the actuator.

O. Lubrication:
   1. Provide totally enclosed actuator gearing with oil or grease filled gear case suitable for operation at any angle.
   2. Actuators requiring special or exotic lubricants are not acceptable.

2.03 ACCESSORIES

A. Software:
   1. Furnish PC-based diagnostic and configuration software to display diagnostic data and configure actuators.
   2. Provide software communications to the valve actuator using Bluetooth wireless communications:
      a. Provide all accessories and drivers required for operation and communications with a standard personal computer running Microsoft Windows.

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

2.04 SPARE PARTS AND SPECIAL TOOLS

A. As specified in Section 01600 - Product Requirements.

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

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

PART 3 EXECUTION

3.01 GENERAL

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

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

3.02 COMMISSIONING

A. As specified in Section 01756 - Commissioning, Section 15958 - Mechanical Equipment Testing, and this Section.

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

C. Source testing:
   1. Design and Performance Test Reports in accordance with AWWA C542.
   2. Test each actuator with a simulated load:
      a. Simulate a typical valve load.
   3. Electrical Instrumentation and Controls:
      a. Test witnessing: not witnessed.
b. Conduct testing as specified in Section 17950 - Commissioning for Instrumentation and Controls.

D. Functional testing:
   1. Installed actuator:
      a. Test witnessing: Witnessed.
      b. Conduct Level 2 General Equipment Performance Tests.
      c. Conduct Level 2 Vibration Tests.
      d. Conduct Level 2 Noise Tests.
   2. Electrical Instrumentation and Controls:
      a. Test witnessing: Witnessed.
      b. Conduct testing as specified in Section 17950 - Commissioning for Instrumentation and Controls.

3.03 MOTORIZED ACTUATOR SCHEDULE

A. Provide all actuators indicated on the Drawings:
   1. Major process actuators are listed in the Intelligent Actuator Schedule in this Section.
   2. The Motorized Actuator Schedule does not include all number and types of actuators required for the Project.

B. Abbreviations relating to type:
   1. SG = Slide Gate.

C. Abbreviations relating to actuator type:
   1. O/C = Open and Close Service.

D. Abbreviations relating to controls:

END OF SECTION
## INTELLIGENT ACTUATOR SCHEDULE

<table>
<thead>
<tr>
<th>Item</th>
<th>Reference DWG</th>
<th>Actuator Type</th>
<th>NEMA Rating</th>
<th>Voltage/Phase/Hz</th>
<th>Controls</th>
<th>Open Time</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>OOC DIVERSION GATE</td>
<td>41M01</td>
<td>SG</td>
<td>O/C</td>
<td>480/3/60</td>
<td>A</td>
<td>180 s</td>
<td></td>
</tr>
<tr>
<td>OOC ISOLATION GATE</td>
<td>41M01</td>
<td>SG</td>
<td>O/C</td>
<td>480/3/60</td>
<td>A</td>
<td>180 s</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**
1. Provide actuators with remote control station.
2. New motorized actuator to be installed on existing equipment. Field verify characteristics prior to sizing motor actuator.
SECTION 15050
COMMON WORK RESULTS FOR MECHANICAL EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Basic design and performance requirements for mechanical equipment.

1.02 REFERENCES

A. American Gear Manufacturer's Association (AGMA) Standards:
   1. 6001-E08 – Design and Selection of Components for Enclosed Gear Drives.

B. American Bearing Manufactures Association (ABMA) Standards:
   1. 9 - Load Ratings and Fatigue Life for Ball Bearings.
   2. 11 - Load Ratings and Fatigue Life for Roller Bearings.

C. American Petroleum Institute (API):
   1. 682 - Shaft Sealing Systems for Centrifugal and Rotary Pumps.

D. ASTM International (ASTM):
   5. A 653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
   7. B 62 - Standard specification for Composition Bronze or Ounce Metal Castings.

E. Food and Drug Administration (FDA).

F. Hydraulic Institute (HI).

G. NSF International (NSF).

1.03 DEFINITIONS

A. Special tools: Tools that have been specifically made for use on unit of equipment for assembly, disassembly, repair, or maintenance.
B. Resonant frequency: That frequency at which a small driving force produces an ever-larger vibration if no dampening exists.

C. Rotational frequency: The revolutions per unit of time usually expressed as revolutions per minute.

D. Critical frequency: Same as resonant frequency for the rotating elements or the installed machine and base.

E. Peak vibration velocity: The root mean square average of the peak velocity of the vibrational movement times the square root of 2 in inches per second.

F. Rotational speed: Same as rotational frequency.

G. Maximum excitation frequency: The excitation frequency with the highest vibration velocity of several excitation frequencies that are a function of the design of a particular machine.

H. Critical speed: Same as critical frequency.

I. Free field noise level: Noise measured without any reflective surfaces (an idealized situation); sound pressure levels at 3 feet from the source unless specified otherwise.

J. Operating weight: The weight of unit plus weight of fluids or solids normally contained in unit during operation.

1.04 SYSTEM DESCRIPTION

A. General:
   1. Product requirements as specified in Section 01600 - Product Requirements.
   2. Project conditions as specified in Section 01610 - Project Design Criteria.
   3. Provisions specified under each technical equipment specification prevail over and supersede conflicting provisions as specified in this Section.
   4. Provide equipment and parts that are suitable for stresses, which may occur during fabrication, transportation, erection, and operation.
   5. Provide equipment that has not been in service prior to delivery, except as required by tests.
   6. Like parts of duplicate units are to be interchangeable.
   7. When 2 or more units of equipment for the same purpose are required, provide products of same manufacturer.
   8. Equipment manufacturer’s responsibility extends to selection and mounting of gear drive units, motors or other prime movers, accessories, and auxiliaries required for proper operation.
   9. When necessary, modify manufacturer's standard product to conform to specified requirements or requirements indicated on the Drawings and contained in Laws and Regulations.
B. Material requirements:
   1. Materials: Suitable for superior corrosion resistance and for services under conditions normally encountered in similar installations.
   2. Dissimilar metals: Separate contacting surfaces with dielectric material.

C. Vibration:
   1. Resonant frequency:
      a. For single speed equipment, ensure there are no natural resonant frequencies within 25 percent above or below the operating rotational frequencies or multiples of the operating rotational frequencies that may be excited by the equipment design.
      b. For variable speed equipment, ensure there are no natural resonant frequencies within 25 percent above or below the range of operating frequencies.
   2. Design, balance, and align equipment to meet the vibration criteria specified in Section 15958 - Mechanical Equipment Testing.

D. Equipment mounting and anchoring:
   1. Mount equipment on cast iron or welded steel bases with structural steel support frames:
      a. Utilize continuous welds to seal seams and contact edges between steel members.
      b. Grind welds smooth.
   2. Provide bases and supports with machined support pads, dowels for alignment of mating of adjacent items, adequate openings to facilitate grouting, and openings for electrical conduits.
   3. Anchorage of equipment to concrete: Perform calculations and determine number, size, type, strength, and location of anchor bolts or other connections.
   4. Provide bolt sleeves for anchor bolts for heavy equipment:
      a. Adjust bolts to final location and fill sleeve with non-shrink grout.
   5. Anchorage of equipment to metal supports: Perform calculations and determine number, size, type, strength, and location of bolts used to connect equipment to metal supports.
   6. Design equipment anchorage, supports, and connections for dead load, running loads, loads during start-up, seismic load, and other loads as required for proper operation of equipment.

E. Seismic design:
   1. Design equipment anchorage and related details for seismic design criteria as specified in Section 01612 - Seismic Design Criteria.
   2. For equipment with operating weight of 400 pounds or more, provide calculations for:
      a. Determine operating weight and centroid of equipment.
      b. Calculate forces and overturning moments.
c. Calculate shear and tension forces in equipment anchorages, supports, and connections.
d. Design equipment anchorage, supports, and connections based on calculated shear and tension forces.

F. Equipment units weighing 50 pounds or more: Provide with lifting lugs or eyes to allow removal with hoist or other lifting device.

1.05 SUBMITTALS

A. Product data:
   1. For each item of equipment:
      a. Design features.
      b. Load capacities.
      c. Efficiency ratings.
      d. Material designations by UNS alloy number or ASTM Specification and Grade.
      e. Data needed to verify compliance with the Specifications.
      f. Catalog data.
      g. Name plate data.
      h. Clearly mark submittal information to show specific items, materials, and accessories or options being furnished.
   2. Gear reduction units:
      a. Engineering information in accordance with applicable AGMA standards.
      b. Gear mesh frequencies.

B. Shop drawings:
   1. Drawings for equipment:
      a. Drawings that include outline drawings, cut-away drawings, parts lists, material specification lists, and other information required to substantiate that proposed equipment complies with specified requirements.
   2. Outline drawings showing equipment, driver, driven equipment, pumps, seal, motor(s) or other specified drivers, variable frequency drive, shafting, U-joints, couplings, drive arrangement, gears, baseplate or support dimensions, anchor bolt sizes and locations, bearings, and other furnished components.
   3. Installation and checkout instructions including leveling and alignment tolerances, grouting, lubrication requirements, and initial start-up procedures.
   4. Wiring, control schematics, control logic diagrams and ladder logic or similar for computer based controls.
   5. Recommended or normal operating parameters such as temperatures and pressures.
   6. Alarm and shutdown set points for all controls furnished.
C. Calculations:
   1. Calculations and other information to substantiate equipment base plates, supports, bolts, anchor bolts, and other connections meet minimum design strength requirements and seismic design criteria specified in Section 01612 - Seismic Design Criteria.
   2. ABMA 9 or ABMA 11 L10 life for bearings calculation methods for drivers, pumps, gears, shafts, motors, and other driveline components with bearings.
   3. Calculations and other information to substantiate that operating rotational frequencies meet the requirements of this Section.
   4. Torsional analysis of power transmission systems: When torsional analysis specified in the equipment sections, provide:
      a. Sketch of system components identifying physical characteristics including mass, diameter, thickness, and stiffness.
      b. Results of analysis including first and second critical frequencies of system components and complete system.
   5. Calculations shall be signed and stamped by a civil or structural engineer registered to practice in the state of California.

D. Quality control submittals:
   2. Submit factory test reports before shipment.
   3. Certified static and dynamic balancing reports for rotating equipment.
   5. Start-up plan: Proposed plan for field-testing equipment as specified in Section 01756 - Commissioning.
   7. Submit material test reports a specified in the equipment sections.

E. Operation and maintenance manuals:
   1. As specified in Section E01430 - Operation and Maintenance Data.
   2. Submit prior to training of District's personnel.
   3. Make available at project site complete copy of manuals for use by field personnel and Engineer during start-up and testing of equipment.
   4. Include manufacturer and model number of every bearing; include calculated ball pass frequencies of the installed equipment for both the inner and outer raceways.
   5. Include motor rotor bar pass frequencies.

F. Project closeout documents: As specified in Section 01770 - Closeout Procedures.
1.06 QUALITY ASSURANCE

A. Manufacturer's field service:
   1. Furnish services of authorized representative specially trained in installation of equipment:
      a. Visit project site and perform tasks necessary to certify installation.
      b. Furnish Certificate of Proper Installation as specified in Section 01756 - Commissioning.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Packing and shipping:
   1. Equipment: Pack in boxes, crates, or otherwise protect from damage and moisture, dust, or dirt during shipment, handling, and storage.
   2. Bearings: Separately pack or otherwise suitably protect during transport.
   3. Spare parts: Deliver in boxes labeled with contents, equipment to which spare parts belong, and name of Contractor.

B. Storage:
   1. Equipment having bearings:
      a. Store in enclosed facilities.
      b. Rotate units at least once per month or more often as recommended by the manufacturer to protect rotating elements and bearings.
   2. Gear boxes: Oil filled or sprayed with rust preventive protective coating.

C. Protection:
   1. Equipment: Protect equipment from deleterious exposure.
   2. Painted surfaces: Protect against impact, abrasion, discoloration, and other damage.

1.08 SEQUENCING AND SCHEDULING

A. Equipment anchoring: Obtain anchoring material and templates or setting drawings from equipment manufacturers in adequate time for anchors to be cast-in-place when concrete is placed.

B. Coordinate details of equipment with other related parts of the Work, including verification that structures, piping, wiring, and equipment components are compatible.

C. General start-up and testing of equipment:
   1. Perform general start-up and testing procedures after operation and maintenance manuals for equipment have been received.
   2. Conduct functional testing of mechanical or electrical systems when each system is substantially complete and after general start-up and testing procedures have been successfully completed.

1.09 MAINTENANCE

A. Special tools:
   1. When specified, provide special tools required for operation and maintenance.
   2. Mark or tag and list such tools in maintenance and operations instructions. Describe use of each tool.

B. Spare parts:
   1. Assume responsibility until turned over to District.
   2. Store in enclosed facilities.
   3. Furnish itemized list and match identification tag attached to every part.
   4. List parts by generic title and identification number.
   5. Furnish name, address, and telephone number of supplier and spare parts warehouse.

1.10 WARRANTY

A. Warrant the Work as specified in General Conditions Section F.

PART 2 PRODUCTS

2.01 MATERIALS

A. Ferrous materials:
   1. Steel for members used in fabrication of assemblies: ASTM A 36.
   2. Iron castings: ASTM A 48, tough, close-grained gray iron, free from blowholes, flaws, and other imperfections.
   3. Ductile iron castings: ASTM A 536, Grade 65-45-12, free from flaws and imperfections.
   5. Expanded metal: ASTM A 36, 13 gauge, 1/2-inch flat pattern expanded metal.

B. Nonferrous materials:
   1. Stainless steel: Type 304 or 316 as specified. Provide L grade where welding required.
   2. Bronze in contact with liquid: Composition of not more than 2 percent aluminum nor more than 6 percent zinc; UNS Alloy C83600, C92200 or C93700 in accordance with ASTM B 61, B 62, B 505, or B 584, when not specified otherwise.
C. Dielectric materials for separation of dissimilar metals:
   1. Neoprene, bituminous impregnated felt, heavy bituminous coatings,
      nonmetallic separators or washers, or other materials.

D. Anchors bolts: minimum 0.5-inch diameter.

E. Non-shrink grout: As specified in Section 03600 - Grouting.

2.02 SHAFT COUPLINGS

A. General:
   1. Type and ratings: Provide nonlubricated type, designed for not less than
      50,000 hours of operating life.
   2. Sizes: Provide as recommended by manufacturer for specific application,
      considering horsepower, speed of rotation, and type of service.
   3. Use: Use of couplings specified in this Section does not relieve Contractor of
      responsibility to provide precision alignment of driver-driven units as required
      by equipment manufacturer and alignment criteria specified elsewhere in this
      Section.

B. Shaft couplings - close coupled: Shaft couplings for close coupled electric motor
   driven equipment 1/2 horsepower or larger and subject to sudden torque reversals
   or shock loading:
   1. Manufacturers: One of the following or equal:
      a. T.B. Woods, Dura-Flex, L-Jaw C-Jaw or G-Jaw.
      b. Lovejoy, S-Flex.
   2. Provide flexible couplings designed to accommodate angular misalignment,
      parallel misalignment, and end float.
   3. Manufacture flexible component of coupling from synthetic rubber, or
      urethane.
   4. Provide service factor of 2.5 for electric motor drives and 3.5 for engine drives.
   5. Do not allow metal-to-metal contact between driver and driven equipment.
   6. Examples of loads where sudden torque reversals may be expected:
      a. Reciprocating pumps, blowers, and compressors.
      b. Conveyor belts.
      c. Reversing equipment.

C. Shaft couplings - direct connected: Shaft couplings for direct connected electric
   motor driven equipment 1/2 horsepower or larger and subject to normal torque,
   non-reversing applications:
   1. Manufacturers: One of the following or equal:
      a. Rexnord - Falk.
      b. T.B. Woods, Dura-Flex, Sure-Flex or Form-Flex.
   2. Provide flexible couplings designed to accommodate shock loading, vibration,
      and shaft misalignment or offset.
   3. Provide flexible connecting element of rubber and reinforcement fibers.
4. Connect stub shafts through collars or round flanges, firmly keyed to their shafts with neoprene cylinders held to individual flanges by through pins.

D. Spacer couplings: Where cartridge type mechanical seals or non-split seals are specified, provide a spacer type coupling of sufficient length to remove the seal without disturbing the driver or driven equipment unless noted otherwise in the individual equipment specifications.

E. Specialized couplings: Where requirements of equipment dictate specialized features, supply coupling recommended for service by manufacturer.

2.03 STUFFING BOX, SEAL CHAMBER, AND SHAFT SEALS

A. General:
   1. Unless otherwise noted in the equipment section, provide cartridge type, double mechanical shaft seals for pumps.
   2. Provide a stuffing box large enough for a double mechanical seal.
   3. Where packing is specified, provide stuffing box large enough to receive a double mechanical seal.
   4. Provide seal or packing flush connections, (3/4-inch size unless another size is indicated on the Drawings).
   5. Provide and route leakage drain line to nearest equipment floor drain indicated on the Drawings.
   6. For pumps with packing, design packing gland to allow adjustment and repacking without dismantling pump except to open up packing box.
   7. Seal or packing flush requirements shall be in accordance with API Standard 682 requirements. Unless otherwise indicated, specified or required by the equipment and seal manufacturers, the following API flushing Plan arrangements shall be utilized as appropriate for the application:
      a. Single seal, clean water applications: Plan 11 (Discharge bypass to seal).
      b. Single seal, vertical pump applications: Plan 13 (Seal bypass to suction).
      c. Single seal, clean hot water (greater than 180 degrees Fahrenheit) applications: Plan 23 (Seal cooler and pumping ring).
      d. Single seal, solids, or contaminants containing water applications: Plan 32 (External seal water- see Carollo typical detail number M262).
      e. Double seal applications: Plan 54 (External seal water- see Carollo typical detail number M262).

B. Packing: When specified in the equipment section of the specifications, provide the following type of packing:
   1. Wastewater, water, and sludge applications:
      a. Asbestos free.
      b. PTFE (Teflon) free.
      c. Braided graphite.
      d. Manufacturers: One of the following or equal:
         1) Chesterton, 1400.
2) John Crane, Inc., equivalent product.

C. Mechanical seals: Provide seal types specified in the equipment sections and as specified:
   1. Provide seal types meeting the following requirements:
      a. Balanced hydraulically.
      b. Spring: Stationary, out of pumping fluid, Hastelloy C; Type Elgiloy or 17-7 PH stainless steel for split seals.
      d. Gland: Type 316L stainless steel.
      e. Set screws: Type 316L stainless steel.
      g. Seal designed to withstand 300 pounds per square inch gauge minimum differential pressures in either direction; no requirement for seal buffer pressure to be maintained when pump is not operational even though process suction head may be present in pump.
   2. Cartridge type single mechanical: Manufacturers: One of the following or equal:
      a. Chesterton, S10.
      b. John Crane, 5610 Series.
   3. Cartridge type double mechanical: Manufacturers: One of the following or equal:
      a. Chesterton, S20.
      b. John Crane, 5620 Series.
   4. Split face single mechanical: Manufacturers: One of the following or equal:
      a. Chesterton, 442.
      b. John Crane, 3740.

2.04 BEARINGS

A. Type: Oil or grease lubricated, ball or roller antifriction type, of standard manufacture.

B. Oil lubricated bearings: Provide either pressure lubricating system or separate oil reservoir splash type system:
   1. Size oil lubrication systems to safely absorb heat energy generated in bearings when equipment is operating under normal conditions and with the temperature 15 degrees Fahrenheit above the maximum design temperature as specified in Section 01610 - Project Design Criteria.
   2. Provide an external oil cooler when required to satisfy the specified operating conditions:
      a. Provide air cooled system if a water-cooling source is not indicated on the Drawings.
      b. Equip oil cooler with a filler pipe and external level gauge.
C. Grease lubricated bearings, except those specified to be factory sealed: Fit with easily accessible grease supply, flush, drain, and relief fittings.
   1. Lubrication lines and fittings:
      a. Lines: Minimum 1/4-inch diameter stainless steel tubing.
      b. Multiple fitting assemblies: Mount fittings together in easily accessible location.
      c. Use standard hydraulic type grease supply fittings:
         1) Manufacturers: One of the following or equal:
            a) Alenite.
            b) Zurk.

D. Ratings: Rated in accordance with ABMA 9 or ABMA 11 L10 life for bearings rating life of not less than 50,000 hours:
   1. Higher ratings, when specified in other sections, supersede preceding requirement.

2.05 WARNING SIGNS

A. Provide for equipment that starts automatically or remotely.

B. Material and size: Metal as specified in Section 10400 - Signage.

C. Colors: Black lettering on yellow background.

D. Text: As specified in Section 10400 - Signage.

2.06 FABRICATION

A. Nameplates:
   1. Engraved or stamped on Type 304 stainless steel and fastened to equipment at factory in an accessible and visible location.
   2. Indicate following information as applicable:
      a. Manufacturer's name.
      b. Equipment model number and serial number.
      c. Maximum and Normal rotating speed.
      d. Horsepower.
      e. Rated capacity.
      f. Service class per applicable standards.
   3. Nameplates for pumps: Include:
      a. Rated total dynamic head in feet of fluid.
      b. Rated flow in gallons per minute.
      c. Impeller, gear, screw, diaphragm, or piston size.
   4. Gear reduction units: Include:
      a. AGMA Class of service.
      b. Service factor.
      c. Input and output speeds.
B. Bolt holes in equipment support frames:
   1. Do not exceed bolt diameter by more than 25 percent, up to limiting maximum diameter oversize of 1/4 inch.

C. Shop finishing:
   1. Provide factory and field coating as specified in Section 09960 - High-Performance Coatings. If not specified in Section 09960 - High-Performance Coatings, provide coating as follows:
      a. Bases and support frames in contact with concrete or other material:
         Coat contacting surfaces with minimum of 2 coats of zinc chromate primer before installation or grouting.
      b. Shop primer for steel and iron surfaces, unless specified otherwise:
         1) Manufacturers: One of the following or equal:
            a) Ameron, Amercoat 185 Universal Primer.
            b) Cook, 391-N-167 Barrier Coat.
            c) Kop-Coat, Pug Primer.
            d) Tnemec, 37-77 Chem-Prime.
            e) Valspar, 13-R-28 Chromox Primer.
      c. Coat machined, polished, and nonferrous surfaces which are not to be painted with rust-preventive compounds:
         1) Manufacturers: One of the following or equal:
            a) Houghton, Rust Veto 344.
            b) Rust-Oleum, R-9.
     e. Finish painting of motors: Shop finish paint with manufacturer's standard coating, unless otherwise specified in Section 09960 - High-Performance Coatings.

2.07 SOURCE QUALITY CONTROL

A. As specified in Section 15958 - Mechanical Equipment Testing for testing requirements and the individual equipment Sections of the Specifications.

PART 3 EXECUTION

3.01 EXAMINATION

A. Inspect all components for shipping damage, conformance to specifications, and proper torques and tightness of fasteners.

3.02 PREPARATION

A. Metal work embedded in concrete:
   1. Accurately place and hold in correct position while concrete is being placed.
2. Clean surface of metal in contact with concrete immediately before concrete is placed.

B. Concrete surfaces designated to receive non-shrink grout:
   1. Heavy sandblast concrete surface in contact with non-shrink grout.
   2. Clean concrete surfaces of sandblasting sand, grease, oil, dirt, and other foreign material that may reduce bond to non-shrink grout.
   3. Saturate concrete with water. Concrete shall be saturated surface damp at time non-shrink grout is placed.

C. Field measurements:
   1. Prior to fabrication of equipment, take measurements for installation of equipment and verify dimensions indicated on the Drawings.
   2. Ensure equipment and ancillary appurtenances fit within available space.

3.03 INSTALLATION

A. Install equipment in accordance with manufacturer's installation instructions and recommendations.

B. Lubrication lines and fittings:
   1. Lines from fittings to point of use: Support and protect.
   2. Fittings:
      a. Bring fittings to outside of equipment in manner such that they are readily accessible from outside without necessity of removing covers, plates, housings, or guards.
      b. Mount fittings together wherever possible using factory-mounted multiple fitting assemblies securely mounted, parallel with equipment lines, and protected from damage.
      c. Fittings for underwater bearings: Bring fittings above water surface and mount on edge of structure above.

C. Alignment of drivers and equipment:
   1. Where drive motors or other drivers are connected to driven equipment by flexible coupling, disconnect coupling halves and align driver and equipment after complete unit has been leveled on its foundation.
   2. Comply with procedures of appropriate HI, AGMA Standards, alignment tolerances of equipment manufacturers and the following requirements to bring components into angular and parallel alignment:
      a. Maximum total coupling offset (not the per plane offset): Not to exceed 0.5 mils per inch of coupling length for spacer couplings based on coupling length (not dial separation).
      b. Utilize jacking screws, wedges, or shims as recommended by the equipment manufacturer and as specified in the equipment sections.
   3. Use reverse-indicator arrangement dial type or laser type alignment indicators: Mount indicators on the driver/coupling flange and
equipment/coupling flange. Alignment instrumentation accuracy shall be sufficient to read angular and radial misalignment at 10 percent or less of the manufacturer’s recommended acceptable misalignment.

4. Alignment and calculations shall include measurement and allowance for thermal growth, spacer coupling length, indicator separation, and axial spacing tolerances of the coupling.

5. When alignment satisfies most stringent tolerance of system components, grout between base and foundation:
   a. Allow minimum 48 hours for grout to harden.
   b. After grout hardens, remove jacking screws, tighten anchor bolts and other connections, and recheck alignment.
   c. Correct alignment as required.

6. After operational testing is complete, dowel motor or drivers and driven equipment:
   a. Comply with manufacturer’s instructions.

D. Grouting equipment bases and baseplates with non-shrink grout:
   1. Grout with non-shrink grout as specified in Section 03600 - Grouting.
   2. Comply with equipment manufacturer’s installation instructions for grouting spaces, and tolerances for level and alignments, both vertical and horizontal.
   3. Grout after piping connections are complete and in alignment with no strain transmitted to equipment.
   4. Grout base when equipment is leveled and in alignment.
   5. Place grout, filling voids under equipment bases and other supports including recesses between anchor bolts and sleeves:
      a. Extend grout to edge of equipment bases or baseplates and bevel at 45 degrees around units.
      b. Grouts must be cut back to the lower edge of baseplates after reaching initial set:
         1) Provide a 45-degree angle cut back.
      c. Finish surfaces with slope that prevents ponding water within grouted areas.

E. Forms and head boxes for non-shrink grouts or non-shrink epoxy grouts:
   1. As specified in Section 03600 - Grouting.

F. Special techniques: Use applicable special tools and equipment, including precision machinist levels, dial indicators, and gauges as required in equipment installations.

G. Tolerances:
   1. Completed equipment installations: Comply with requirements for intended use and specified vibration and noise tolerances.

H. Warning signs: Mount securely with stainless fasteners at equipment that can be started automatically or from remote locations.
3.04 FIELD QUALITY CONTROL

A. Test equipment as specified in Section 15958 - Mechanical Equipment Testing and the individual equipment Section of the Specifications.

B. Perform operational testing as required by Section 01756 - Commissioning.

3.05 MANUFACTURER'S REPRESENTATIVE

A. Field checkout: Before field-testing and start-up, provide services of factory-trained field service representative to certify the equipment has been installed, aligned, and checked in accordance with the manufacturer's instructions and the Specifications.

B. Testing: Provide services of factory trained representative to observe and advise the Contractor during field quality control testing.

C. Training: When training is specified, provide services of factory-trained representative to perform training as specified in Section 01756 - Commissioning.

END OF SECTION
SECTION 15052
COMMON WORK RESULTS FOR GENERAL PIPING

PART 1     GENERAL

1.01 SUMMARY

A. Section includes: Basic materials and methods for metallic and plastic piping systems.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):

B. American Water Work Association (AWWA):

C. ASTM International (ASTM):
   1. A193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.


E. NSF International (NSF).

1.03 DEFINITIONS

A. Buried pipes: Pipes that are buried in the soil with or without a concrete pipe encasement.
B. Exposed pipe: Pipes that are located above ground, or located inside a structure, supported by a structure, or cast into a concrete structure.

C. Underground pipes: Buried pipes - see Article 1.03, Paragraph A. above.

D. Underwater pipes: Pipes below the top of walls in basins or tanks containing water.

E. Wet wall: A wall with water on at least 1 side.

PART 2 PRODUCTS

2.01 GENERAL

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

2.02 ESCUTCHEONS

A. Material: Chrome-plated steel plate.

B. Manufacturers: One of the following or equal:
   1. Dearborn Brass Co., Model Number 5358.
   2. Keeney Manufacturing Co., Model Number 102 or Number 105.

2.03 LINK TYPE SEALS

A. Characteristics:
   1. Modular mechanical type, consisting of interlocking neoprene or synthetic rubber links shaped to continuously fill the annular space between the pipe and wall opening.
   2. Links to form a continuous rubber belt around the pipe.
   3. Provide a nylon polymer pressure plate with Type 316 stainless steel hardware. Isolate pressure plate from contact with wall sleeve.
   4. Hardware to be Type 316 stainless steel:
      a. Provide anti-galling lubricant for threads.

B. One of the following or equal:
   1. Link-Seal.
   2. Pipe Linx.

2.04 FLANGE BOLTS AND nuts

A. General:
   1. Washer:
      a. Provide a washer for each nut.
      b. Washer shall be of the same material as the nut.
   2. Nuts: Heavy hex-head.
3. Cut and finish flange bolts to project a maximum of 1/4 inch beyond outside face of nut after assembly.
4. Tap holes for cap screws or stud bolts when used.
5. Lubricant for stainless steel bolts and nuts:
   a. Chloride-free.
   b. Manufacturers: One of the following or equal:
      1) Huskey FG-1800 Anti-Seize.
      2) Weicon Anti-Seize High-Tech.
6. On buried pipes:
   a. Bolts: ASTM A193, Grade B8M.
   b. Nuts: ASTM A194, Grade 8M.
   c. Encase in 2 layers of loose polyethylene wrap in accordance with AWWA C105.

B. Plastic pipe:
   1. On exposed pipes:
      a. Bolts: ASTM A307, Grade B.
      b. Nuts: ASTM A563, Grade A.
      c. Bolts and Nuts: Hot-dip galvanized in accordance with ASTM F2329.
   2. On buried, underwater pipes and pipes adjacent to wet walls:
      a. Bolts: ASTM A193, Grade B8M.
      b. Nuts: ASTM A194, Grade 8M.

2.05 GASKETS

A. General:
   1. Gaskets shall be suitable for the specific fluids, pressure, and temperature conditions.

B. Gaskets for flanged joints in polyvinyl chloride and polyethylene piping:
   1. Suitable for pressures equal to and less than 150 pounds per square inch gauge, with low flange bolt loadings, temperatures equal to and less than 120 degrees Fahrenheit, and polymer, chlorine, caustic solutions, and other chemicals, except chemicals which liberate free fluorine including fluorochemicals and gaseous fluorine.
   2. Material: 0.125-inch thick Viton rubber.
   3. Manufacturers: One of the following or equal:
      a. Garlock.
      b. John Crane, similar product.

C. Gaskets for non-steam cleaned ductile iron and steel piping:
   1. Suitable for pressures equal to and less than 150 pounds per square inch gauge, temperatures equal to and less than 250 degrees Fahrenheit, and raw sewage service.
   2. Gasket material:
      a. EPDM with minimum Shore A hardness value of 70.
b. Reinforcement: Cloth or synthetic fiber.
c. Thickness: Minimum 3/32-inch thick for less than 10-inch pipe; minimum 1/8-inch thick for 10-inch and larger pipe.

3. Manufacturers: One of the following or equal:
   a. Pipe less than 48 inches in diameter:
      1) Garlock, Style 7797.
      2) John Crane, similar product.
   b. Pipe 48 inches in diameter and larger:
      1) Garlock, Style 3760.
      2) John Crane, similar product.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. Piping drawings:
      a. Except in details, piping is indicated diagrammatically. Not every offset and fitting, or structural difficulty that may be encountered has been indicated on the Drawings. Sizes and locations are indicated on the Drawings.
      b. Perform minor modifications to piping alignment where necessary to avoid structural, mechanical, or other type of obstructions that cannot be removed or changed:
         1) Modifications are intended to be of minor scope, not involving a change to the design concept or a change to the Contract Price or Contract Times.
   2. Piping alternatives:
      a. Provide piping as specified in this Section, unless indicated on the Drawings or specified otherwise.
      b. Alternative pipe ratings:
         1) Piping with greater pressure rating than specified may be substituted in lieu of specified piping without changes to the Contract Price.
         2) Piping of different material may not be substituted in lieu of specified piping.
      c. Valves in piping sections: Capable of withstanding specified test pressures for piping sections and fabricated with ends to fit piping.
      d. Grooved joints: Use couplings, flange adapters, and fittings of the same manufacturer:
         1) Manufacturer’s factory trained representative:
            a) Provide on-site training for Contractor’s field personnel.
            b) Periodically visit the jobsite to verify Contractor is following best recommended practices.
         2) Distributor’s representative is not considered qualified to conduct the training or jobsite visits.
Flanged joints: where 1 of the joining flanges is raised face type, provide a matching raised face type flange for the other joining flange.

3. Unless otherwise indicated on the Drawings, piping at pipe joints, fittings, couplings, and equipment shall be installed without rotation, angular deflection, vertical offset, or horizontal offset.

B. Wall and slab penetrations:
   1. Provide sleeves for piping penetrations through aboveground masonry and concrete walls, floors, ceilings, roofs, unless specified or otherwise indicated on the Drawings.
   2. Provide flexibility in piping connecting to structures to accommodate movement due to soil settlement and earthquakes. Provide flexibility using details indicated on the Drawings.
   3. Core drilled openings:
      a. Do not damage or cut existing reinforcing bars, electrical conduits, or other items embedded in the existing concrete without acceptance by Engineer.
      b. Determine location of reinforcing bars or other obstructions with a non-destructive indicator device.
      c. Remove dust and debris from hole using compressed air.

C. Exposed piping:
   1. Install exposed piping in straight runs parallel to the axes of structures, unless otherwise indicated on the Drawings:
      a. Install piping runs plumb and level, unless otherwise indicated on the Drawings:
         1) Slope plumbing drain piping with a minimum of 1/4 inch per foot downward in the direction of flow.
   2. Install exposed piping after installing equipment and after piping and fitting locations have been determined.
   3. Support piping: As specified in Sections 15061 - Pipe Supports:
      a. Do not transfer pipe loads and strain to equipment.
   4. In addition to the joints indicated on the Drawings, provide unions, flexible couplings, flanged joints, flanged coupling adapters, and other types of joints or means which are compatible with and suitable for the piping system, and necessary to allow ready assembly and disassembly of the piping.
   5. Assemble piping without distortion or stresses caused by misalignment:
      a. Match and properly orient flanges, unions, flexible couplings, and other connections.
      b. Do not subject piping to bending or other undue stresses when fitting piping.
      c. Do not correct defective orientation or alignment by distorting flanged joints or subjecting flange bolts to bending or other undue stresses.
      d. Flange bolts, union halves, flexible connectors, and other connection elements shall slip freely into place.
e. Alter piping assembly to fit, when proper fit is not obtained.
f. Install eccentric reducers or increasers with the top horizontal for pump suction piping.

D. Buried piping:
1. Bury piping with minimum 3-foot cover without air traps, unless otherwise indicated on the Drawings.
2. Where 2 similar services run parallel to each other, piping for such services may be laid in the same trench:
   a. Lay piping with sufficient room for assembly and disassembly of joints, for thrust blocks, for other structures, and to meet separation requirements of public health authorities having jurisdiction.
3. Laying piping:
   a. Lay piping in finished trenches free from water or debris. Begin at the lowest point with bell ends up slope.
   b. Place piping with top or bottom markings with markings in proper position.
   c. Lay piping on an unyielding foundation with uniform bearing under the full length of barrels.
   d. Where joints require external grouting, banding, or pointing, provide space under and immediately in front of the bell end of each section laid with sufficient shape and size for grouting, banding, or pointing of joints.
   e. At the end of each day's construction, plug open ends of piping temporarily to prevent entrance of debris or animals.

F. Venting piping under pressure:
1. Lay piping under pressure flat or at a continuous slope without air traps, unless otherwise indicated on the Drawings.
2. Install plug valves as air bleeder cocks at high points in piping:
   a. Provide 1-inch plug valves for water lines, and 2-inch plug valves for sewage and sludge lines, unless otherwise indicated on the Drawings.
3. Provide additional pipe taps with plug cocks and riser pipes along piping as required for venting during initial filling, disinfecting, and sampling.
4. Before piping is placed into service, close plug valves and install plugs. Protect plugs and plug valves from corrosion in as specified in Section 09960 - High-Performance Coatings.

G. Restraining buried piping:
1. Restrain piping at valves and at fittings where piping changes direction, changes sizes, and at ends:
   a. When piping is underground, use mechanical restraints or push-on restraints.
   b. Determine thrust forces by multiplying the nominal cross-sectional area of the piping by design test pressure of the piping.
2. Provide restraints with ample size to withstand thrust forces resulting from test pressures:
   a. During testing, provide suitable temporary restraints where piping does not require permanent restraints.

3. Place concrete thrust blocks against undisturbed soil.

4. Place concrete so piping joints, fittings, and other appurtenances are accessible for assembly and disassembly.

5. Provide underground mechanical restraints where specified in the Piping Schedule.

H. Restraining above ground piping:
   1. Restrain piping at valves and at fittings where piping changes direction, changes sizes, and at ends:
      a. When piping is aboveground or underwater, use mechanical or structural restraints.
      b. Determine thrust forces by multiplying the exposed cross-sectional area of the piping by design test pressure of the piping.
   2. Provide restraints with ample size to withstand thrust forces resulting from test pressures:
      a. During testing, provide suitable temporary restraints where piping does not require permanent restraints.

I. Connections to existing piping:
   1. Expose existing piping to which connections are to be made with sufficient time to permit, where necessary, field adjustments in line, grade, or fittings:
      a. Protect domestic water/potable water supplies from contamination:
         1) Make connections between domestic water supply and other water systems in accordance with requirements of public health authorities.
         2) Provide devices approved by District of domestic water supply system to prevent flow from other sources into the domestic supply system.
   2. Make connections to existing piping and valves after sections of new piping to be connected have been tested and found satisfactory.
   3. Provide sleeves, flanges, nipples, couplings, adapters, and other fittings needed to install or attach new fittings to existing piping and to make connections to existing piping.
   4. For flanged connections, provide stainless steel bolts with isolation bushings and washers, and full-face flange gaskets.

J. Connections between ferrous and nonferrous metals:
   1. Connect ferrous and nonferrous metal piping, tubing, and fittings with dielectric couplings especially designed for the prevention of chemical reactions between dissimilar metals.
   2. Nonferrous metals include aluminum, copper, and copper alloys.
K. Flanged connections between dissimilar metals such as ductile iron pipe and steel pipe:
   1. Provide stainless steel bolts with isolation bushings and washers, and full-face flange gaskets.

3.02 CLEANING

A. Piping cleaning:
   1. Upon completion of installation, clean piping interior of foreign matter and debris.
   2. Perform special cleaning when required by the Contract Documents.

B. Conduct pressure and leak test, as specified.

3.03 PIPING SCHEDULE

A. Abbreviations:
   1. The following pipe services are used in the schedule:

<table>
<thead>
<tr>
<th>Service</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposed</td>
<td>Piping exposed, visible to the operator, in a building, pipe rack, basement, any piping above grade</td>
</tr>
<tr>
<td>Buried</td>
<td>Piping underground or grade or under slabs</td>
</tr>
<tr>
<td>Submerged</td>
<td>Piping under water and piping located in the area between the water surface and under grating/walkway/slabs</td>
</tr>
</tbody>
</table>

   2. The following abbreviations used in the column of test method refer to the respective methods specified in Section 15956 - Piping Systems Testing:

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>HH</td>
<td>High Head Method</td>
</tr>
<tr>
<td>LH</td>
<td>Low Head Method</td>
</tr>
</tbody>
</table>

   3. Abbreviations to designate piping include the following:

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIP</td>
<td>Ductile Iron Piping</td>
</tr>
<tr>
<td>DR</td>
<td>Dimension Ratio</td>
</tr>
<tr>
<td>HDPE</td>
<td>High Density Polyethylene</td>
</tr>
<tr>
<td>PVC</td>
<td>Polyvinyl Chloride</td>
</tr>
<tr>
<td>Sch.</td>
<td>Schedule, Followed by the Designation</td>
</tr>
</tbody>
</table>
4. Abbreviations to designate pipe lining include the following:

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM</td>
<td>Cement Mortar</td>
</tr>
</tbody>
</table>

5. Abbreviations to designate pipe coating include the following:

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM</td>
<td>Cement Mortar</td>
</tr>
<tr>
<td>HSE</td>
<td>High Solids Epoxy System per Section 09960 - High-Performance Coatings.</td>
</tr>
<tr>
<td>EPU</td>
<td>High Solids Epoxy and Polyurethane System per Section 09960 - High-Performance Coatings.</td>
</tr>
<tr>
<td>PE</td>
<td>Polyethylene Encasement</td>
</tr>
<tr>
<td>WAE</td>
<td>Waterborne Acrylic Emulsion</td>
</tr>
</tbody>
</table>

6. Abbreviations designate pipe service include the following:

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>Drain</td>
</tr>
<tr>
<td>FBW</td>
<td>Filter Backwash</td>
</tr>
<tr>
<td>OOC</td>
<td>Out of Compliance</td>
</tr>
<tr>
<td>SDR</td>
<td>Storm Drain</td>
</tr>
<tr>
<td>TE</td>
<td>Tertiary Effluent</td>
</tr>
</tbody>
</table>

(The Piping Schedule follows on the next page).
<table>
<thead>
<tr>
<th>Service</th>
<th>Nominal Pipe Size</th>
<th>Material</th>
<th>Joints/Fittings</th>
<th>Lining</th>
<th>Coating</th>
<th>Test Pressure/Method</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>D – Drain</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exposed</td>
<td>ALL</td>
<td>DIP Class 53</td>
<td>Flanged</td>
<td>CM</td>
<td>EPU</td>
<td>20 psig LH</td>
<td></td>
</tr>
<tr>
<td>Submerged</td>
<td>ALL</td>
<td>DIP Class 53</td>
<td>Flanged</td>
<td>CM</td>
<td>HSE</td>
<td>20 psig LH</td>
<td></td>
</tr>
<tr>
<td>FBW – Filter Backwash</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buried</td>
<td>All</td>
<td>DIP Class 53</td>
<td>Restrained</td>
<td>CM</td>
<td>Double PE</td>
<td>50 psig HH</td>
<td></td>
</tr>
<tr>
<td>OOC – Out of Compliance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buried</td>
<td>All</td>
<td>Steel</td>
<td>Double pass full welded</td>
<td>CM</td>
<td>CM</td>
<td>20 psig HH</td>
<td></td>
</tr>
<tr>
<td>SDR – Storm Drain</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exposed</td>
<td>Under 6”</td>
<td>PVC Sch. 80</td>
<td>Socket Solvent Welded</td>
<td>WAE</td>
<td></td>
<td>50 psig HH</td>
<td>Drawings are based on HDPE. For PVC, use appropriate size with same internal diameter</td>
</tr>
<tr>
<td>Buried</td>
<td>36” and larger</td>
<td>HDPE, DR-17 or PVC, C900, DR-25</td>
<td>Welded</td>
<td></td>
<td></td>
<td>10 psig LH</td>
<td></td>
</tr>
<tr>
<td>Submerged</td>
<td>Under 6”</td>
<td>PVC Sch. 80</td>
<td>Socket Solvent Welded</td>
<td></td>
<td></td>
<td>50 psig HH</td>
<td></td>
</tr>
<tr>
<td>TE – Tertiary Effluent</td>
<td></td>
<td></td>
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<td>HDPE, DR-17 or PVC, C900, DR-25</td>
<td>Welded</td>
<td></td>
<td></td>
<td>20 psig HH</td>
<td>Drawings are based on HDPE. For PVC, use appropriate size with same internal diameter</td>
</tr>
</tbody>
</table>

END OF SECTION
SECTION 15061
PIPE SUPPORTS

PART 1  GENERAL

1.01  SUMMARY

A. Section includes: Supports for pipe, fittings, valves, and appurtenances.

1.02  REFERENCES

A. ASTM International (ASTM):

B. Manufacturer's Standardization Society (MSS):

1.03  SUBMITTALS

A. Submit as specified in General Conditions

B. Product data.
   1. Design features.
   2. Load capacities.
   3. Material designations by UNS alloy number or ASTM Specification and Grade.
   4. Data needed to verify compliance with the Specifications.
   5. Catalog data.
   6. Clearly mark submittal information to show specific items, materials, and accessories or options being furnished.

1.04  Warranty

A. Provide warranty as specified in General Conditions.

PART 2  PRODUCTS

2.01  GENERAL

A. As specified in Section 01600 - Product Requirements.
2.02 MATERIALS

A. General:
   1. Stainless steel.
      a. Finish requirements: Remove free iron, heat tint oxides, weld scale, and
         other impurities, and obtain a passive finished surface.
      b. At the shop, perform pickling and passivation on all surfaces inside and
         out in accordance with ASTM A380 or A967.
         1) Passivation treatments using citric acid are not allowed.
      c. Field welding is prohibited unless specifically allowed by the District. All
         field welds shall be passivated.

B. Outdoor areas: Areas exposed to the natural outdoor environment:
   1. Type 316 Stainless Steel.

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

2.03 PIPE SUPPORTS

A. Standard U-bolt: MSS SP-58, Type 24:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Nibco-Tolco, Figure 110.
         2) Cooper B-Line Systems, Inc., Figure B3188.
         3) FM Stainless Fasteners, Figure 37.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 137.
         2) Bergen-Power, Figure 283.
         3) Cooper B-Line Systems, Inc., Figure B3188.

B. Riser clamps: MSS SP-58, Type 8:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Cooper B-Line Systems, Inc., Figure B3373.
         2) FM Stainless Fasteners, Figure 61.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 261.
         2) Bergen-Power, Figure 126.
         3) Cooper B-Line Systems, Inc., Figure B3373.

C. Pipe clamps: MSS SP-58, Type 4:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Nibco-Tolco, Figure 4.
2) Cooper B-Line Systems, Inc., Figure 3140.

b. For all other piping, unless indicated on the Drawings:
   1) Anvil International, Figure 212.
   2) Bergen-Power, Figure 175.
   3) Cooper B-Line Systems, Inc., Figure B3140.

D. Floor stand or stanchion saddles: MSS SP-58, Type 37. Provided with U-bolt hold down yokes:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Nibco-Tolco, Figure 318.
         2) FM Stainless Fasteners, Figure 59.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 259.
         2) Bergen-Power, Figure 125.
         3) Cooper B-Line Systems, Inc., Figure B3090.
      c. Threaded pipe stand support stanchion. Match pipe support material.
         1) Anvil International, Figure 63T.
         2) Bergen-Power, Figure 138.
         3) Cooper B-Line Systems Inc., Figure B3088ST.

PART 3 EXECUTION

3.01 INSTALLATION

A. Support, suspend, or anchor exposed pipe, fittings, valves, and appurtenances to prevent sagging, overstressing, or movement of piping; and to prevent thrusts or loads on or against connected pumps, blowers, and other equipment.

B. Field verify support location, orientation, and configuration to eliminate interferences prior to fabrication of supports.

C. Carefully determine locations of inserts. Anchor to formwork prior to placing concrete.

D. Use flush shells only where indicated on the Drawings.

E. Do not use anchors relying on deformation of lead alloy.

F. Do not use powder-actuated fasteners for securing metallic conduit or steel pipe larger than 1-inch to concrete, masonry, or wood.

G. Suspend pipe hangers from hanger rods and secure with double nuts.

H. Install continuously threaded hanger rods only where indicated on the Drawings.
I. Use adjustable ring hangers or adjustable clevis hangers for 4-inch and smaller diameter pipe.

J. Use adjustable clevis hangers for pipe larger than 4 inches in diameter.

K. Secure pipes with double nutted U-bolts or suspend pipes from hanger rods and hangers.
   1. For stainless steel piping, use stainless steel U-bolts.
   2. For all other piping, use galvanized U-bolts.

L. Support spacing:
   1. Support 2-inch and smaller piping on horizontal and vertical runs at maximum 5 feet on center, unless otherwise specified.
   2. Support larger than 2-inch piping on horizontal and vertical runs at maximum 10 feet on center, unless otherwise specified.
   3. Support exposed polyvinyl chloride and other plastic pipes at maximum 5 feet on center, regardless of size.
   4. Support tubing, PVC pipe 1-inch and smaller, copper pipe and tubing, fiber-reinforced plastic pipe or duct, and rubber hose and tubing at intervals close enough to prevent sagging greater than 1/4-inch between supports.
   5. Do not suspend or support valves, pipe and fittings from another pipe or conduit.

M. Install supports at:
   1. Any change in direction.
   2. Both sides of flexible pipe connections.
   4. Floor penetrations.
   5. Connections to pumps, blowers, and other equipment.
   6. Valves and appurtenances.

N. Securely anchor plastic pipe, valves, and headers to prevent movement during operation of valves.

O. Anchor plastic pipe between expansion loops and direction changes to prevent axial movement through anchors.

P. Provide elbows or tees supported from floors with base fittings where indicated on the Drawings.

Q. Support base fittings with metal supports or when indicated on the Drawings support on concrete piers.

R. Do not use chains, plumbers' straps, wire, or similar devices for permanently suspending, supporting, or restraining pipes.

S. Support plumbing drainage and vents in accordance with plumbing code as specified in Section 01410 - Regulatory Requirements.
T. Supports, clamps, brackets, and portions of support system bearing against copper pipe: Copper plated, copper throughout, or isolated with neoprene or polyvinyl chloride tape.

U. Where pipe is insulated, install over-sized supports and hangers.

V. Install insulation shield in accordance with MSS SP-58, Type 40. Shield shall be galvanized steel unless otherwise specified or indicated on the Drawings.

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

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

END OF SECTION
SECTION 15075
EQUIPMENT IDENTIFICATION

PART 1   GENERAL

1.01 SUMMARY

A. Section includes:
   1. Equipment nameplates.
   2. Special items.

1.02 SUBMITTAL

A. Submit as specified in General Conditions.

B. Shop drawings:
   1. Product data.
   2. Installation instructions.

C. Samples.

PART 2   PRODUCTS

2.01 EQUIPMENT NAMEPLATES

A. Material and fabrication:
   1. Stainless steel sheet engraved or stamped with text, holes drilled, or punch for
      fasteners.

B. Fasteners:
   1. Number 4 or larger oval head stainless steel screws or drive pins.

C. Text:
   1. Manufacturer’s name, equipment model number and serial number, identification tag number; and when appropriate, drive speed, motor horsepower with rated capacity, pump rated total dynamic head, and impeller size.
2.02 SPECIAL ITEMS

A. In addition, special coating of following items will be required:

<table>
<thead>
<tr>
<th>Item</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valve handwheels and levers</td>
<td>Red</td>
</tr>
<tr>
<td>Steel guard posts</td>
<td>In accordance with standard details</td>
</tr>
</tbody>
</table>

B. Paint minimum 2 inches high numbers on or adjacent to accessible valves, pumps, flowmeters, and other items of equipment which are indicated on the Drawings or in Specifications by number.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify satisfactory conditions of substrate for applying identification.

B. Verify that conditions are satisfactory for installation and application of products as specified in Section 01600 - Product Requirements.

3.02 PREPARATION

A. Prepare and coat surfaces of special items as specified in Section 09960 – High-Performance Coatings.

B. Prepare surface in accordance with product manufacturer's instructions.

END OF SECTION
SECTION 15076
PIPE IDENTIFICATION

PART 1    GENERAL

1.01 SUMMARY

A. Section includes: Pipe identification including the following:
   1. Pipe identification by color and legend.
   2. Underground warning tape.
   3. Tracer wire.
   5. Valve identification.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):

1.03 SUBMITTALS

A. Submit as specified in General Conditions.

B. Submit following:
   1. Product data.
   2. Samples.
   3. Manufacturer's installation instructions.
   4. Submit following as specified in Section 01770 - Closeout Procedures:
      a. Operation and Maintenance Data.
      b. Warranty.

PART 2    PRODUCTS

2.01 ABOVE GROUND AND IN-CHASE PIPE IDENTIFICATION

A. Manufacturers:
   1. One of the following or equal:
      b. Lab Safety Supply.
      c. Marking Services, Inc.
B. Materials:
1. Pipe markers: Self-adhesive vinyl, suitable for outdoor application from -40 degrees to 180 degrees Fahrenheit; in accordance with ASME A13.1 requirements.
   a. Lettering:

<table>
<thead>
<tr>
<th>Nominal Pipe Diameter</th>
<th>Lettering Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 1.5 inches</td>
<td>1/2-inch</td>
</tr>
<tr>
<td>1.5 inches to 2 inches</td>
<td>3/4-inch</td>
</tr>
<tr>
<td>2.5 inches to 6 inches</td>
<td>1-1/4 inches</td>
</tr>
<tr>
<td>8 inches to 10 inches</td>
<td>2-1/2 inches</td>
</tr>
<tr>
<td>Over 10 inches</td>
<td>3-1/2 inches</td>
</tr>
</tbody>
</table>

   b. Marker colors:

<table>
<thead>
<tr>
<th>Service</th>
<th>Lettering</th>
<th>Background</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water, nontoxic solutions or low hazard liquids</td>
<td>White</td>
<td>Green</td>
</tr>
</tbody>
</table>

2. Coating: As specified in Section 09960 - High-Performance Coatings.
3. Pipe identification tags: Aluminum or stainless steel with stamped-in 1/4-inch high identifying lettering.
4. Pipe identification tag chains: Aluminum or stainless steel.
5. Snap-on markers: Markers with 3/4-inch high letters for 3/4 to 4-inch pipe or covering, or 5-inch high letters for 5-inch or larger pipe or cover:
   a. Manufacturers: One of following or equal:
      1) Brady BradySnap-On B-915.
      2) Seton Setmark.

2.02 BURIED PIPELINE IDENTIFICATION

A. Underground warning tape:
1. Manufacturer: One of the following or equal:
   a. Seton Name Plate Co.
   b. T. Christy Enterprises, Inc.
2. Material:
   a. Polyethylene tape for prolonged underground use.
   b. Minimum tape thickness: 4 mils.
   c. Overall tape width: 6 inches.
   d. Message: “CAUTION” with the name of the service followed by “LINE BURIED BELOW.” in black lettering on colored background in accordance with approved APWA colors.
      1) Water: Blue.
      2) Sewer: Green.
3) Telephone: Orange.
4) Gas and other services: Yellow.

B. Tracer wire:
   1. Manufacturers: One of the following or equal:
      a. Kris-Tech Wire.
      b. Corrpro.
   2. Materials: One of the following or equal:
      a. Solid copper conductor.
      b. Thickness minimum: 14 gauge.
      c. Insulation:
         1) Match insulation color to the color of the pipe being installed.
         2) UF type (THWN, or THHN), direct bury.
         3) 30 mil HMWPE.
   3. Splicing Kit:
      a. Manufacturers: One of the following or equal:
   4. Station Box:
      a. Lid and collar materials: Cast iron.
      b. Able to withstand heavy traffic loading.
      c. Manufacturers: One of the following or equal:
         1) Farwest Corrosion Control Co, Glenn 4 Test Station.

2.03 VALVE AND GATE IDENTIFICATION

A. Provide valve and gate schedule for each valve and gate in the Work with the following information:
   1. Identification number.
   2. Location.
   3. Type.
   5. Normal operating position.

B. Identification tag requirements.
   1. Diameter: 2 inches.
   2. Material:
      b. Buried applications with concrete marker: Brass.
      c. Above ground and in-chase applications: 19 gauge aluminum or PVC.
   3. Stamp tags in 1/4-inch high letter:
   4. Provide non-corrosive metal wire suitable for attaching the tag to the operator base.
   5. Secure tags to valve or gate:
      a. Attach tags in such a way as to allow free and full operation of the valve or gate.
C. Submittal requirements:
   1. Submit 2 samples of the type of tag proposed and the manufacturer’s standard color chart and letter styles to the Engineer for review.

D. Manufacturer: The following or equal:
   1. Seton Name Plate Co.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify satisfactory conditions of substrate for applying identification.

B. Verify that conditions are satisfactory for installation and application of products as specified in Section 01600 - Product Requirements.

3.02 PREPARATION

A. Prepare and coat surfaces as specified in Section 09960 - High-Performance Coatings.

B. Prepare surface in accordance with product manufacturer's instructions.

3.03 ABOVE GROUND AND IN-CHASE PIPING IDENTIFICATION

A. Identify exposed piping and piping, in accessible chases with lettering or tags designating service of each piping system with flow directional arrows and color code.

B. Color code:
   1. Paint piping with colors as scheduled in Piping Color Code and Marker Schedule.

C. Lettering and flow direction arrows:
   1. Stencil lettering on painted bands or use snap-on markers on pipe to identify pipe. When stenciling, stencil 3/4-inch high letters on 3/4- through 4-inch pipe or coverings, or 5-inch high letters on 5-inch and larger pipe or coverings.
   2. Provide lettering and flow direction arrows near equipment served, adjacent to valves, both sides of walls and floors where pipe passes through, at each branch or tee, and at intervals of not more than 50 feet in straight runs of pipe.

D. Where scheduled, space 6-inch wide bands along stainless steel pipe at 10-foot intervals and other pipe at 5-foot intervals.

E. Label chemical tank fill pipelines at locations which are visible from chemical fill stations.
F. Metal tags:
   1. Where outside diameter of pipe or pipe covering is 5/8-inch or smaller, provide metal pipe identification tags instead of lettering.
   2. Fasten pipe identification tags to pipe with chain.
   3. Where tags are used, color code pipe as scheduled.

3.04 BURIED PIPING IDENTIFICATION

A. Underground warning tape:
   1. Place continuous run of warning tape in pipe trench, 12 inches above the pipe.

B. Tracer wire:
   1. Install on all waterlines and/or non-metallic pipe. Reclaimed waterlines and force mains whether or not telemetry wire is buried with the pipe.
   2. Install an electrically continuous run of tracer wire along the entire length of the pipe with wire terminations in valve boxes, vaults, or structures. Loop 2 feet of wire in valve box within 2 feet of fire hydrant or EMWD marker post.
   3. Install tracer wire on top of the pipe and secure to pipe with tape a minimum of every 10 feet.
   4. Where approved by the Engineer, splice sections of wire together using a crimpable butt connector
      a. Twisting the wires together is not acceptable.
   5. Tracer wire shall be brought to the surface at 660 feet O.C. max by fire hydrants or install EMWD marker posts (B-665). Give stations at valve boxes. (For tract construction chisel "LW" in face of curb in lieu of marker posts).
   6. Use cast iron cover labeled water, sewer, or reclaimed (reclaimed to be painted lavender).
   7. For pipe depths greater than 8 feet tracer wire shall be placed above pipe at max 8 feet depth. Marker tape shall be placed 1 feet above the locator wire
   8. Locatibility test is to be performed on all locator wires.

3.05 APPLICATION

A. Identify piping with legend markers, directional arrow markers, and number markers; use self-adhesive arrow roll tape to secure ends of piping markers and indicate flow direction.

B. Provide legend markers, directional arrow markers, and number markers where piping passes through walls or floors, at piping intersections and at maximum 15-foot spacing on piping runs.

C. Provide piping marker letters and colors as scheduled.

D. Place markers on piping so they are visible from operator's position in walkway or working platform near piping. Locate markers along horizontal centerline of pipe, unless better visibility is achieved elsewhere.
### 3.06 PIPING COLOR CODE AND MARKER SCHEDULE

<table>
<thead>
<tr>
<th>Service Fluid</th>
<th>Pipe Color</th>
<th>Marker Legend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drain</td>
<td>Charcoal</td>
<td>DRAIN</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Letters</th>
<th>Color of Pipe</th>
<th>Color of Bands</th>
<th>Color of Letters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drain</td>
<td>Dark Gray</td>
<td>None</td>
<td>White</td>
</tr>
</tbody>
</table>

END OF SECTION
SECTION 15110
COMMON WORK RESULTS FOR VALVES

PART 1   GENERAL

1.01 SUMMARY

A. Section includes: Basic requirements for valves.

1.02 REFERENCES

A. American Water Works Association (AWWA):

B. ASTM International (ASTM):

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

D. Society for Protective Coatings (SSPC):
   1. SP7 - Brush-Off Blast Cleaning.
   2. SP10 - Near-White Blast Cleaning.

1.03 DESIGN REQUIREMENTS

A. Pressure rating:
   1. Suitable for service under minimum working pressures of 150 pounds per square inch gauge.
   2. When a piping system is specified in the Piping Schedule to be tested at a pressure greater than 150 pounds per square inch gauge, provide valves for that piping system with design working pressure which is sufficient to withstand the test pressure.

B. Valve to piping connections:
   1. Valves 3-inch nominal size and larger: Flanged ends.
   2. Valves less than 3-inch nominal size: Screwed ends.
   3. Plastic valves in plastic piping:
      a. Up to 2.5 inches: Provide solvent or heat welded unions.
b. 3 inches and above: Provide solvent or heat welded flanges.

1.04 SUBMITTALS

A. Submit as specified in the General Conditions.

B. Product data:
   1. Submit the following information for each valve:
      a. Valve type, size, pressure rating, Cv factor.
      b. Coatings.
      c. Manual valve actuators:
         1) Information on valve actuator including size, manufacturer, model number.
      d. Certified drawings with description of component parts, dimensions, weights, and materials of construction.
      e. Certifications of reference standard compliance:
         1) Submit certification that the valves and coatings are suitable in potable water applications in accordance with NSF 61.
      f. Clearly mark submittal information to show specific items, materials, and accessories or options being furnished.

C. Operation and maintenance data:
   1. Furnish bound sets of installation, operation, and maintenance instructions for each type of manual valve 4 inch in nominal size and larger, and all non-manual valves. Include information on valve operators in operation and maintenance instruction manual.

1.05 QUALITY ASSURANCE

A. Manufacturer qualifications:
   1. Valves manufactured by manufacturers whose valves have had successful operational experience in comparable service.

1.06 DELIVERY STORAGE AND HANDLING

A. Protect valves and protective coatings from damage during handling and installation; repair coating where damaged.

PART 2 PRODUCTS

2.01 MATERIALS

A. Stainless steel: In accordance with ASTM A 167, Type 316, or Type 304, UNS Alloy S31600 or S30400.
B. Valve and operator bolts and nuts:
   1. Fabricated of stainless steel for the following installation conditions:
      a. Submerged in sewage or water.
      b. In an enclosed space above sewage or water.
      c. In structures containing sewage or water, below top of walls.
      d. At openings in concrete or metal decks.
   2. Where dissimilar metals are being bolted, use stainless steel bolts with isolation bushings and washers.
   3. Underground bolts: Low-alloy steel in accordance with AWWA C111/A21.11.

C. Bronze and brass alloys: Use bronze and brass alloys with not more than 6 percent zinc and not more than 2 percent aluminum in the manufacture of valve parts; UNS Alloy C83600 or C92200 unless specified otherwise.

D. Valve bodies: Cast iron in accordance with ASTM A 126, Class 30 minimum or ductile iron in accordance with ASTM A 536, Grade 65-45-12 minimum unless specified otherwise.

2.02 INTERIOR PROTECTIVE LINING

A. When specified in the particular valve specification, provide valves with type of protective lining specified in the particular valve Specification.

B. Apply protective lining to interior, non-working surfaces, except stainless steel surfaces.

C. Lining types:
   1. Fusion bonded epoxy:
      a. Manufacturers: One of the following or equal:
         1) 3-M Company, ScotchKote 134; certified to NSF 61 for drinking water use.
      b. Clean surfaces in accordance with SSPC SP 7 or SP 10, as recommended by epoxy manufacturer.
      c. Apply in accordance with manufacturer's published instructions.
      d. Lining thickness: 0.010 to 0.012 inches except that:
         1) Lining thickness in grooves for gaskets: 0.005 inches.
         2) Do not coat seat grooves in valves with bonded seat.
      e. Quality control:
         1) Lining thickness: Measured with a non-destructive magnetic type thickness gauge.
         2) Verify lining integrity with a wet sponge-testing unit operating at approximately 60 Volts, or as recommended by the lining manufacturer.
         3) Consider tests successful when lining thickness meets specified requirements and when no pinholes are found.
4) Correct defective lining disclosed by unsuccessful tests, and repeat test.
5) Repair pinholes with liquid epoxy recommended by manufacturer of the epoxy used for lining.

2. High solids epoxy:
   a. Product equivalent to high solids epoxy specified in Section 09960 - High-Performance Coatings.
      1) Certified in accordance with NSF 61 for drinking water use.
      2) Interior: Coat valve interior with manufacturer's equivalent high performance high solids epoxy coating system with a certifiable performance history for the service conditions and as approved by the Engineer. Manufacturer shall provide for approval, coating information sufficient to allow Engineer to assess equivalence to the specified high solids epoxy coating specified in Section 09960 - High-Performance Coatings.
   b. Clean surfaces to meet SP-7 or SP-10, or as recommended by coating manufacturer.
   c. Quality control: After coating is cured, check coated surface for porosity with a holiday detector set at 1,800 Volts, or as recommended by coating manufacturer.
      1) Repair holidays and other irregularities and retest coating.
      2) Repeat procedure until holidays and other irregularities are corrected.

2.03 VALVE OPERATORS

A. Valve operator "Open" direction: Open counterclockwise.

B. Provide valves located below operating level or deck with extensions for key operation or floor stands and handwheels.

C. Provide manually operated valves located not more than 6 feet above the operating level with tee handles, wrenches, or handwheels.
   1. Make the valve operator more conveniently accessible by rolling valves, located more than 5 feet but less than 6 feet above the operating level, toward the operating side.
   2. Secure tee handles and wrenches to the valve head or stem, except where a handle or wrench so secured constitutes a hazard to personnel; in which case, stow handle or wrench immediately adjacent to the valve on or in a suitable hanger, bracket, or receptacle.

D. Fit valves located more than 6 feet above operating level with chain operated handles or valve wheels.
   1. Chains: Sufficient length to reach approximately 4 feet above the operating level.
2. Where chains constitute a nuisance or hazard to operating personnel, provide holdbacks or other means for keeping the chains out of the way.

E. Provide an operator shaft extension from valve or valve operator to finished grade or deck level when buried valves, and other valves located below the operating deck or level, are specified or indicated on the Drawings to be key operated; provide 2 inch square AWWA operating nut, and box and cover as specified, or a cover where a box is not required.

PART 3 EXECUTION

3.01 EXAMINATION

A. Preparation prior to installation:
   1. Install valves after the required submittal on installation has been accepted.
   2. Determine after flanged valves and flanged check valves are selected, the face-to-face dimensions of flanged valves and flanged check valves.

B. Fabricate piping to lengths taking into account the dimensions of flanged valves and flanged check valves.

3.02 INSTALLATION

A. Provide incidental work and materials necessary for installation of valves including flange gaskets, flange bolts and nuts, valve boxes and covers, concrete bases, blocking, and protective coating.

B. Where needed, furnish and install additional valves for proper operation and maintenance of equipment and plant facilities under the following circumstances:
   1. Where such additional valves are required for operation and maintenance of the particular equipment furnished by Contractor.
   2. Where such additional valves are required as a result of a substitution or change initiated by Contractor.

C. Install valves with their stems in vertical position above the pipe, except as follows:
   1. Butterfly valves, gate valves aboveground, globe valves, ball valves, and angle valves may be installed with their stems in the horizontal position.
   2. Install buried plug valves with geared operators with their stems in a horizontal position.

D. Install valves so that handles clear obstructions when the valves are operated from fully open to fully closed.

E. Place top of valve boxes flush with finished grade or as otherwise indicated on the Drawings.
F. Valves with threaded connections:
   1. Install valves by applying wrench on end of valve nearest the joint to prevent distortion of the valve body.
   2. Apply pipe joint compound or Teflon tape on external (male) threads to prevent forcing compound into valve seat area.

G. Valves with flanged connections:
   1. Align flanges and gasket carefully before tightening flange bolts.
   2. When flanges are aligned, install bolts and hand tighten.
   3. Tighten nuts opposite each other with equal tension before moving to next pair of nuts.

H. Valves with soldered connections:
   1. Do not overheat connection to prevent damage to resilient seats and metal seat rings.
   2. Position valves in full open position before starting soldering procedure.
   3. Apply heat to piping rather than to valve body.

3.03 FIELD APPLIED COATING OF VALVE EXTERIOR

A. Match color and be compatible with manufacturer’s coating system and as specified in Section 09960 - High-Performance Coatings.
   1. When shop applied finish coating matches field applied coating on adjacent piping, touch up shop coating in damaged areas in accordance with instructions recommended by the paint manufacturer.
   2. When shop applied coating does not match field coating on adjacent piping, or when damage has occurred to the shop applied coating that requires more than touchup, blast clean valve surfaces or utilize other surface preparation recommended by the manufacturer of the coating material and apply the coating system used for coating adjacent piping.

3.04 COMMISSIONING

A. As specified in Section 01756 - Commissioning and this Section.

B. Manufacturer services from each manufacturer for all valves supplied:
   1. Provide Manufacturer’s Certificate of Source Testing.
   2. Provide Manufacturer’s Certificate of Installation and Functionality Compliance.

C. As specified elsewhere for specific valve types, sizes or actuators.
   1. Source testing.

END OF SECTION
SECTION 15111
BALL VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Ball valves.

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

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):

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

C. ASTM International (ASTM):
      Welding, for High-Temperature Service.
   3. A351 - Standard Specification for Castings, Austenitic, for Pressure-Containing
      Parts.

1.03 SYSTEM DESCRIPTION

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

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

1.04 SUBMITTALS

A. Submit as specified in General Conditions.

B. Product data: As specified in Section 15110 - Common Work Results for Valves:
   1. Metal body ball valves: 6 inches and larger only: Submit affidavit of compliance
      in accordance with AWWA C507.
   2. Operation and maintenance manual.
C. Commissioning submittals:
   1. Provide Manufacturer’s Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.

1.05 WARRANTY

A. Provide warranty as specified in General Conditions.

PART 2 PRODUCTS

2.01 PLASTIC BODY BALL VALVES

A. Manufacturers: One of the following or equal:
   1. Asahi America.
   2. Chemtrol Division, NIBCO, Inc.

B. General:
   1. Type: Non-lubricated and capable of sealing in either flow direction.
   2. End connections: True union; solvent or heat welded to piping.
   3. Operator handle: Lever.

C. Materials:
   2. Ball: Polyvinyl chloride (PVC).
   4. O-rings: EPDM.

PART 3 EXECUTION

3.01 INSTALLATION

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

B. Special techniques:
   1. PVC ball valves for hypochlorite service:
      a. Provide valve with factory drilled 0.125-inch hole in the upstream side of the ball.
      b. Provide an engraved plastic tag permanently attached to the valve stem stating "One side of ball drilled for hypochlorite service".
3.02 FIELD APPLIED COATING OF VALVE EXTERIOR

A. Match color and be compatible with manufacturer’s coating system and as specified in Section 09960 - High-Performance Coatings.
   1. When shop applied finish coating matches field applied coating on adjacent piping, touch up shop coating in damaged areas in accordance with instructions recommended by the paint manufacturer.
   2. When shop applied coating does not match field coating on adjacent piping, or when damage has occurred to the shop applied coating that requires more than touchup, blast clean valve surfaces or utilize other surface preparation recommended by the manufacturer of the coating material and apply the coating system used for coating adjacent piping.

3.03 COMMISSIONING

A. As specified in Section 01756 - Commissioning and this Section.

B. Manufacturer services:
   1. Provide certificates:
      a. Manufacturer's Certificate of Installation and Functionality Compliance.

C. Functional testing:
   1. Valves:
      a. Test witnessing: Witnessed.
      b. Conduct pressure and leak test, as specified in Section 15110 - Common Work Results for Valves.

END OF SECTION
SECTION 15114
CHECK VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Check valves.

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

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   2. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Inch Standard.

B. American Water Works Association (AWWA):
   1. C508 - Standard for Swing-Check Valves for Waterworks Service 2 Inch Through 24 Inch NPS.

C. ASTM International (ASTM):

1.03 SYSTEM DESCRIPTION

A. Design requirements:
   1. Check valves: When not otherwise specified as indicated on the Drawings, provide check valves suitable for service as follows:
      a. In either horizontal or vertical position.
      b. Suitable for service working pressures up to 150 pounds per square inch gauge.

1.04 SUBMITTALS

A. Submit as specified in General Conditions.
B. Product data: As specified in Section 15110 - Common Work Results for Valves.

C. Commissioning submittals:
   1. Provide Manufacturer’s Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.

1.05 WARRANTY

A. Provide warranty as specified in General Conditions.

PART 2 PRODUCTS

2.01 SWING CHECK VALVES

A. Valves 4 inches through 24 inches:
   1. Manufacturers: One of the following or equal:
      a. Kennedy, Figure 106LW or M&H, Model 159.
      c. APCO Model 250.
      d. Crispin SWL Series.
   2. Valve design:
      a. In accordance with AWWA C508.
      b. Constructed to permit top entry and removal of internal components without removing the valve.
      c. Equipped with outside lever and weight.
   3. Materials:
      a. Body: Cast iron, ASTM A126 Class B or ASTM A536 Grade 65-45-12 Ductile Iron.
      b. Disc:
         1) Valve disc shall be ASTM A126 cast iron, ASTM A536 ductile iron, or ASTM B584 bronze.
         2) 4-inch valves: Bronze or stainless steel rings and seats.
         3) 6 inches and larger valves: Bronze-faced or stainless steel rings and seats.
         4) Rubber seat Buna-N or EPDM.
      c. Hinge pins: Stainless steel.

2.02 INLINE CHECK VALVES

A. Manufacturers: One of the following or equal:
   1. Tide Flex, CheckMate®.

B. Design:
   1. Maximum downstream head: 20 feet.
   2. With internal pressure 1 to 2 inches w.c. above backpressure, bill of valve opens, allowing flow.
3. With backpressure 1 to 2 inches w.c. above internal pressure, bill of valve closes, preventing backflow.
4. Suitable for sewage and storm water applications.
5. Slip-in body.

C. Materials of construction:
   1. Single piece elastomer construction with internal polyester fabric reinforcing all vulcanized into a composite material.
      a. Internal reinforcing sufficient to maintain structural integrity under the specified operating conditions.
      b. Exterior applications require coating for UV protection and to resist pest gnawing.
   2. Elastomeric material: EPDM.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install valves as specified in Section 15110 - Common Work Results for Valves and the manufacturer's instructions.

3.02 FIELD APPLIED COATING OF VALVE EXTERIOR

A. Match color and be compatible with manufacturer’s coating system and as specified in Section 09960 - High-Performance Coatings.
   1. When shop applied finish coating matches field applied coating on adjacent piping, touch up shop coating in damaged areas in accordance with instructions recommended by the paint manufacturer.
   2. When shop applied coating does not match field coating on adjacent piping, or when damage has occurred to the shop applied coating that requires more than touchup, blast clean valve surfaces or utilize other surface preparation recommended by the manufacturer of the coating material and apply the coating system used for coating adjacent piping.

3.03 COMMISSIONING

A. As specified in Section 01756 - Commissioning and this Section.

B. Manufacturer services:
   1. Provide certificates:
      a. Manufacturer's Certificate of Installation and Functionality Compliance.

C. Functional testing:
   1. Valves:
      a. Test witnessing: Witnessed.
b. Conduct pressure and leak test, as specified in Section 15110 - Common Work Results for Valves.

END OF SECTION
SECTION 15119
AIR AND VACUUM RELIEF VALVES

PART 1  GENERAL

1.01  SUMMARY
A. Section Includes: Combination air valves.
B. Inclusion of a specific manufacturer’s name in the Specifications does not mean that the specific manufacturer’s standard product will be acceptable. Specified manufacturer’s or other manufacturer’s standard product shall be modified as required to meet the Specifications.

1.02  REFERENCES
A. American Society for Testing and Materials (ASTM):

1.03  SUBMITTALS
A. Manufacturers shall submit calculations and recommendations for orifice sizes, seat material, and seat hardness.

PART 2  PRODUCTS

2.01  COMBINATION AIR RELEASE VALVES - SEWAGE SERVICE
A. Manufacturers: One of the following or equal:
   2. Multiplex Manufacturing Company, Crispin Series US.
B. Design:
   1. Operation: Automatic exhaust and intake of large quantities of air from pipelines during filling and draining respectively and release of accumulated air while pipeline is under pressure.
   2. Design: Utilize compound lever system in conjunction with large and small orifices.
3. Internal parts removable through top cover without removing valve from pipeline.

4. Pressure Rating: 150 pounds per square inch.

5. Connections:
   a. Inlet size as indicated on the Drawings.
   b. For 2-inch valves:
      1) 2-inch threaded inlet and 1-inch threaded outlet for flows less than 1,000 gpm.
      2) 2-inch threaded inlet and 2-inch threaded outlet for flows 1,000 gpm and greater.
   c. For inlet greater than 2 inches, outlet size equals inlet size. Inlet and outlet shall be threaded.

6. Provide Valve With:
   a. Inlet shutoff valve.
   b. Two blowoff valves for backflushing.
   c. 10 feet of hose with quick disconnect couplings.

C. Materials:
   1. Body: Cast iron.
   2. Float: Stainless steel.
   3. Needle: Buna N.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install as specified in Section 15110 - Common Work Results for Valves and manufacturer’s instructions.

B. Install air release valves and air and vacuum valves with suitable discharge lines to nearest equipment drain.

3.02 FIELD APPLIED COATING OF VALVE EXTERIOR

A. Match color and be compatible with manufacturer’s coating system and as specified in Section 09960 - High-Performance Coating.
   1. When shop applied finish coating matches field applied coating on adjacent piping, touch up shop coating in damaged areas in accordance with instructions recommended by the manufacturer.
   2. When shop applied coating does not match field coating on adjacent piping, or when damage has occurred to the shop applied coating that requires more than touchup, remove existing coating by abrasive blast cleaning and apply the coating system used for coating adjacent piping in accordance with Section 09960 - High-Performance Coating.
      a. Submerged valves: SP-5 White Metal Blast cleaning.
b. Other valves: SP-10 Near-white blast cleaning.

3.03 COMMISSIONING

A. As specified in Section 01756 - Commissioning and this Section.

B. Manufacturer services:
   1. Provide certificates:
      a. Manufacturer's Certificate of Installation and Functionality Compliance.

C. Functional testing:
   1. Valves:
      a. Test witnessing: Witnessed.
      b. Conduct pressure and leak test as specified in Section 15110 - Common Work Results for Valves.

END OF SECTION
SECTION 15120

PIPING SPECIALTIES

PART 1  GENERAL

1.01  SUMMARY

A. Section includes: Piping specialties including:
   1. Pipe saddles.

1.02  REFERENCES

A. American Society of Mechanical Engineers (ASME):

B. American Water Works Association (AWWA):

C. ASTM International (ASTM):
   2. A193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.

1.03  SUBMITTALS

A. Submit as specified in General Conditions.

B. Product data:
   1. For each piping product in this Section as applicable:
      a. Design features.
      b. Load capacities.
      c. Material designations by UNS alloy number or ASTM Specification and Grade.
      d. Data needed to verify compliance with the Specifications.
      e. Catalog data.
      f. Clearly mark submittal information to show specific items, materials, and accessories or options being furnished.
C. Manufacturer’s Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning:
   1. Provide as specified in this Section.

1.04 WARRANTY

A. Provide warranty as specified in General Conditions.

PART 2 PRODUCTS

2.01 GENERAL

A. As specified in Section 01600 - Product Requirements.

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

2.02 PIPE SADDLES

A. Manufacturers: One of the following or equal:
   1. BTR Inc. / Smith-Blair, Inc., Style 317.
   2. Romac Industries, Inc., Style 202S.

B. Materials:
   1. Pipe saddles: Ductile iron.
   2. Straps, bolts, and nuts: Type 304 stainless steel with Teflon coating on nuts.
   3. Gaskets: EPDM.

2.03 SHIPPING

A. As specified in Section 01600 - Product Requirements.

PART 3 EXECUTION

3.01 GENERAL

A. As specified in Section 01600 - Product Requirements.

B. Drawings supersede conflicts with this Section.

3.02 INSTALLATION

A. Pipe saddles:
   1. Coat threads on bolts with anti-gall coating prior to installation.

3.03 COMMISSIONING

A. As specified in Section 01756 - Commissioning and this Section.
B. Manufacturer services:
   1. Provide Manufacturer’s Certificate of Installation and Functionality Compliance.
   2. Provide Manufacturer’s Representative Onsite:
      a. Installation: 1 trip / 1 day each:
         1) Installation consultation and advice.
         2) Installation inspection.

C. Field testing:
   1. As specified in Section 15052 - Common Work Results for General Piping.
   2. Protect bellows type expansion joints and vibration control joints.

END OF SECTION
SECTION 15121
PIPE COUPLINGS

PART 1    GENERAL

1.01  SUMMARY

A. Section Includes: Flexible couplings, flanged coupling adapters, and restrained flexible couplings.

B. Inclusion of a specific manufacturer’s name in the Specifications does not mean that the specific manufacturer’s standard product will be acceptable. Specified manufacturer’s or other manufacturer’s standard product shall be modified as required to meet the Specifications.

1.02  REFERENCES

A. American National Standards Institute/American Society of Mechanical Engineers (ANSI/ASME).


C. Society of Automotive Engineers (SAE).

1.03  SUBMITTALS

A. Shop drawings detailing dimensions and materials.

B. Piping Layout Drawings: Coordinate preparation of required piping layout drawings such that coupling center sleeve sizes are clearly identified on drawings.

C. Manufacturer's published installation instructions.

PART 2    PRODUCTS

2.01  PIPE COUPLINGS IN DUCTILE IRON PIPING

A. Flanged Coupling Adapters, greater than 12-inch size:
   1. Manufacturers: One of the following or equal:
      a. Dresser Industries, Style 128-W.
      b. Romac Industries, Inc., Style FC400.
   2. Materials:
      a. Flange and Flanged Body: Steel, ASTM A53 or ASTM A512.
b. Follower Ring: Rolled steel.
c. Bolts and Hex Nuts:
   1) Aboveground: High strength, low alloy steel.
   2) Buried and Underwater: Type 316 stainless steel bolts.

3. Flange Design: In accordance with AWWA Class D with ANSI 150 pound drilling.

4. Coating and Lining: Provide product with shop-applied primer, which is compatible with finish coating to be applied in the field.

B. Restrained Flexible Couplings:
   1. For restraining and joining two plain end pipes of the same or dissimilar materials such as ductile iron, steel, PVC (C900 or ASTM D2241).
      a. Manufacturer: One of the following, or equal:
         1) EBAA Iron Series 3800 Mega-Coupling.
   2. Materials:
      b. Sleeve, Ductile Iron, ASTM A536.
      c. Bolts and Hex Nuts:
         1) Aboveground: High strength, low alloy steel.
         d. Buried and Underwater: Type 316 stainless steel.
   3. Coupling System:
      a. The restraint mechanism shall incorporate the following:
         1) A plurality of individually actuated gripping surfaces.
         2) Torque limiting twist off nuts to insure proper actuating of the restraint devices.
      b. The coupling sleeve shall be coated with a minimum of 15 mils of fusion bonded epoxy conforming to the applicable requirements of ANSI/AWWA C213 and shall be:
         1) Holiday test with a 1,500-volt spark test.
      c. The restraint device shall be coated using MEGA-BOND or an approved equal.
      d. Ductile iron components of the restraint system shall meet or exceed the requirements of ASTM A536 and shall be tested in accordance with the said standard.
      e. The coupling system shall meet the applicable requirements of AWWA C219, ANSI/AWWA C111/A21.11 and ASTM D2000.

2.02 PIPE COUPLINGS FOR CARBON STEEL PIPING

A. Flexible couplings:
   1. Manufacturers: One of the following or equal:
      c. Romac Ind., Inc., Style 511 or Style 400.
2. **Materials:**
   a. **Center sleeve and follower flanges:** Ductile iron or low carbon steel having a minimum yield strength of 30,000 pounds per square inch.
   b. **Bolts and hex nuts:**
      1) **Aboveground:** High strength, low alloy steel in accordance with AWWA C111.
      2) **Buried and underwater:** Type 316 stainless steel bolts in accordance with ASTM F593.

3. **Coating and lining:** Manufacturer’s standard fusion bonded epoxy, NSF 61 certified.

4. **Center sleeve dimensions:** Provide center sleeves with lengths in accordance with following table:

**B. Restrained flange coupling adapters:**
1. **Manufacturers:** One of the following or equal:
   a. Romac Ind., Inc., Style RFCA.
   b. Star Pipe Products, 3200 StarFlange™.
2. **Materials:**
   a. **Flange and flanged body:** Ductile iron in accordance with ASTM A536.
   b. **Follower ring:** Lug type restraint system.
      1) **Follower ring:** Ductile iron in accordance with ASTM A536.
      2) **Restraining lugs:** Ductile iron in accordance with ASTM A536.
         a) Designed to contact the pipe and apply forces evenly.
      3) **Restraining bolts:** Ductile iron in accordance with ASTM A536. Bolt heads shall be designed to twist off when the proper torque has been applied.
   c. **Bolts and hex nuts:**
      1) **Aboveground:** High-strength, low-alloy steel in accordance with AWWA C111.
      2) **Buried and underwater:** Type 316 stainless steel bolts in accordance with ASTM F593.

3. **Flange design:** Class D steel ring flange in accordance with AWWA C207 compatible with ANSI Class 125 and 150 bolt circles.
4. **Coating and lining:** Manufacturer’s standard fusion bonded epoxy certified in accordance with NSF 61.

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**PART 3 EXECUTION**

**3.01 INSTALLATION**

A. **In underground and underwater installations,** coat the exterior of coupling with a protective coating in accordance with manufacturer’s instructions.

B. **Joints and flexible connections shall be installed centered** with no angular deflection unless otherwise indicated on the Drawings.
C. Flexible couplings and flange coupling adapters: Install with gap between pipe ends in accordance with the following table unless a greater gap is indicated on the Drawings. Maximum gap tolerance shall be within 1/8 inch.
1. Install flexible coupling with pipe gap located in middle of center sleeve.
2. Install flanged coupling adapter with end of plain end pipe in middle of flanged coupling body.

<table>
<thead>
<tr>
<th>Center Ring Length</th>
<th>Gap Dimension and Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 inch through 6 inch</td>
<td>3/8 inch</td>
</tr>
<tr>
<td>7 inch</td>
<td>5/8 inch</td>
</tr>
<tr>
<td>10 inch and greater</td>
<td>7/8 inch</td>
</tr>
</tbody>
</table>

D. Provide harnesses (tie-downs) for flexible couplings unless otherwise indicated on the Drawings with a written note.
1. Design harnesses (tie-downs) for the test pressures as specified in the Piping Schedule in Section 15052 - Common Work Results for General Piping.

END OF SECTION
SECTION 15211

DUCTILE IRON PIPE: AWWA C151

PART 1  GENERAL

1.01  SUMMARY

A. Section includes: Ductile iron pipe, joints, fittings, gaskets, and pipe linings and coatings.

1.02  REFERENCES

A. American Society of Mechanical Engineers (ASME):

B. American Water Works Association (AWWA):
   2. C105 - Polyethylene Encasement for Ductile-Iron Pipe Systems.

C. American Welding Society (AWS):

D. ASTM International (ASTM):

E. Ductile Iron Pipe Research Association (DIPRA):
F. NACE International (NACE):
   1. SP0188 - Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates.

G. National Association of Pipe Fabricators, Inc. (NAPF):
   1. 500-03 - Surface Preparation Standard for Ductile Iron Pipe and Fittings in Exposed Locations Receiving Special External Coatings and/or Special Internal Linings.

H. Society for Protective Coatings (SSPC):
   1. PA-2 - Measurement of Dry Coating Thickness With Magnetic Gages.

1.03 SYSTEM DESCRIPTION

A. Thrust restraint system design:
   1. Design restrained joint thrust restraint system.
   2. Determine the length of pipe that must be restrained on each side of the focus of a thrust load in accordance with the procedures and criteria established by the DIPRA Thrust Restraint Design Manual as specified in Piping Schedule in Section 15052 - Common Work Results for General Piping and the following additional criteria:
      a. Design pressure: Test pressure.
      b. Laying condition: Type 5 in accordance with AWWA C150.
      c. Soil designation: Silt 1 as defined by DIPRA.
      d. Unit friction resistance: Based upon polyethylene encasement of pipe.
      e. Safety factor: 1.5 (for thrust restraint calculations only).

1.04 SUBMITTALS

A. Submit as specified in General Specifications.

B. Product data: As specified in Section 15052 - Common Work Results for General Piping.

C. Shop drawings:
   1. Detailed layout drawings showing alignment of pipes, location of valves, fittings, and appurtenances, types of joints, and connections to pipelines or structures.
   2. Thrust restraint systems layouts.
   3. Photographs, drawings, and descriptions of fittings, gaskets, couplings, grooving of pipe and fittings, pipe linings, and coatings.

D. Calculations:
   1. Calculations for thrust restraint system design.
1.05 QUALITY ASSURANCE

A. Pre-installation meeting:
   1. Arrange for Coating Manufacturer’s Technical Representative to attend preconstruction conferences, and to make periodic visits to factory or shop to inspect surface preparation of pipe, fittings, and accessories; and to inspect application of linings to interior and coatings to exterior of pipe, fittings, and accessories.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Block associated fittings for shipment to prevent damage to coatings and linings.

B. Carefully handle fittings during loading, unloading, and installation:
   1. Do not drop fittings material from cars or trucks.
   2. Lower fittings by mechanical means.
   3. Do not drop or pound fittings to fit grade.

C. Ceramic epoxy lined fittings must be handled only from the outside:
   1. No forks, chains, straps, hooks, or other lifting device shall be placed inside the pipe or fittings for lifting, positioning, or laying.

D. Protect gaskets and polyethylene encasement from long-term exposure to sunlight.

E. Store piping, fittings, and other accessories such that they do not accumulate and hold rainwater, dirt, and debris.

PART 2 PRODUCTS

2.01 MANUFACTURED UNITS

A. Fittings:
   1. Ductile iron in accordance with AWWA C110.
   2. Joint type: Same as that of the associated piping as specified in Section 15052 - Common Work Results for General Piping.
   3. Plain end-to-flanged joint connectors using setscrews are not acceptable.

B. Pipe and fitting linings:
   1. Cement-mortar lining:
      a. In accordance with AWWA C104, apply cement-mortar on clean bare metal surfaces. Extend to faces of flanges, ends of spigots, and shoulders of hubs.
      b. Minimum lining thickness: Standard in accordance with AWWA C104.
      c. Type of cement: Type II.
C. Coatings:
   2. Primer:
      a. Factory applied for field coating.
      b. Compatible with materials as specified in Section 09960 - High-Performance Coatings.

2.02 POLYETHYLENE ENCASEMENT

A. General:
   1. Polyethylene encasement shall be supplied by the pipe manufacturer.

B. Materials: Supply one of the following polyethylene encasements:
   1. 2 layers of linear low-density polyethylene (LLDPE) film, minimum thickness of 8 mils in accordance with AWWA C105; or,
   2. Single layer of high-density, cross-laminated polyethylene (HDCLPE) film, minimum thickness of 4 mils in accordance with AWWA C105.
   3. Single layer of V-Bio* enhanced polyethylene encasement (3 layers of co-extruded LLDPE film with anti-microbial additive and volatile corrosion inhibitor infused on the inside surface), meeting all requirements of AWWA C105.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. Install ductile iron piping in accordance with AWWA C600, modified as specified in Section 15052 - Common Work Results for General Piping.
   2. For underground piping, the trenching, backfill, and compaction: As specified in Section 02318 - Trenching.

B. Polyethylene encasement:
   1. Wrap all buried ductile iron pipe and fittings in 2 layers of loose low density polyethylene wrap or a single layer of high-density polyethylene wrap in accordance with AWWA C105.
   2. Polyethylene encasement shall be continuous and terminated neatly at connections to below grade equipment or structures.
   3. At wall penetrations, extend encasement to the wall and neatly terminate.
   4. At slab penetrations, extend encasement to 2 inches below the top of slab and neatly terminate.
   5. When rising vertically in unimproved areas, extend encasement 6 inches above existing grade and neatly terminate.
   6. Repair tears and make joints with 2 layers of plastic tape.
   7. All work shall be inspected prior to backfilling of pipe and associated items.
C. Joints:

1. Install types of joints as specified in the piping schedule provided in Section 15052 - Common Work Results for General Piping.
2. Mechanical joints are not acceptable in above ground applications.
3. Field closure for restrained push-on pipe:
   a. Locate field closures in areas where thrust calculations demonstrate restraint is not required.
4. Grooved joints:
   a. Install piping with grooved joints where specified in the piping schedule as specified in Section 15052 - Common Work Results for General Piping or indicated on the Drawings.
   b. Assemble grooved joints in accordance with manufacturer's published instructions.
   c. Support grooved-end pipe in accordance with manufacturer’s published instructions.
      1) Install at least 1 support between consecutive couplings.

END OF SECTION
SECTION 15241
HIGH DENSITY POLYETHYLENE PLASTIC (HDPE) PIPE: AWWA C906

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: High Density Polyethylene Pipe (HDPE), and fittings.

1.02 REFERENCES

A. ASTM International (ASTM):

B. Plastic Pipe Institute (PPI):
   1. PE 4710.

1.03 ABBREVIATIONS

A. HDPE: High-density polyethylene pipe.

B. ID: Inside diameter of piping or tubing.

C. OD: Outside diameter.

D. SDR: Standard dimension ratio.
1.04 SUBMITTALS

A. Submit as specified in General Conditions.

B. Shop drawings:
   1. Detailed layout drawings showing alignment of pipes, location of valves, fittings, and appurtenances, types of joints, and connections to pipelines or structures.

C. Product data: As specified in Section 15052 - Common Work Results for General Piping:
   1. Describe materials and installation equipment including fusion machine. Include optimum range of fusion conditions such as fusion temperature, interface pressure, and cooling time Pipe loads and structural calculations.
   2. Installation instructions.

D. Qualifications of installation crew for high-density polyethylene pipe including qualifications of the fusion machine technician. Furnish proof of training in the use of fusion equipment.

1.05 QUALITY ASSURANCE

A. Markings on the pipe shall be in accordance with AWWA C906.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Protect piping materials from sunlight, scoring, and distortion.

B. Do not allow surface temperatures on pipe and fittings to exceed 120 degrees Fahrenheit.

C. Store and handle PE pipe and fittings as recommended by manufacturer in published instructions.

PART 2 PRODUCTS

2.01 MATERIALS

A. Extruding and molding material: Virgin material containing no scrap, regrind, or rework material except where permitted in the referenced standards.

B. Fittings: Same material as the pipe and of equal or greater pressure rating.

2.02 HDPE PIPE

A. General:
   1. Pipe and fittings: High-density polyethylene.
2. Dimensions of pipe and fittings: Based on controlled outside diameter in accordance with ASTM F714:
   a. SDR: As given in Piping Schedule, Section 15052 - Common Work Results for General Piping; or, if not given, minimum SDR equals 9.
   b. Pipe Diameter: IPS dimensions as specified in Section 15052 - Common Work Results for General Piping Pipe Schedule.

3. Pipe, fittings, and adapters: Furnished by the same manufacturer, or compatible with components in the same system and with components of other systems to which connected.

B. Materials:
   1. Manufacturers: One of the following or equal:
      a. Performance Pipe.
      b. Isco Industries.
   2. Polyethylene: As listed by the PPI under the designation PE 4710; and have a minimum cell classification, in accordance with ASTM D3350, of 445574C:
      a. Pipe and fittings: Manufactured from material with the same cell classification.
      b. Manufacturer shall certify that pipe and fittings meet the above classifications.
   3. Polyethylene fittings and custom fabrications:
      a. Molded or fabricated.
      b. Butt fusion outlets shall be made to the same outside diameter, wall thickness, and tolerances as the mating pipe.
      c. All fittings and custom fabrications shall be fully rated for the same internal pressure as the mating pipe.
      d. Pressure de-rated fabricated fittings are prohibited.
   4. Molded fittings:
      a. Manufactured in accordance with ASTM D3261, Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing, and shall be so marked.
      b. Each production lot of molded fittings shall be subjected to the tests required under ASTM D3261.
      c. Do not use molded fittings for pipe over 12-inch diameter.
   5. X-ray inspection: The Manufacturer shall submit samples from each molded fittings production lot to x-ray inspection for voids, and shall certify that voids were not found.
   6. Fabricated fittings:
      a. Made by heat fusion joining specially machined shapes cut from pipe, polyethylene sheet stock, or molded fittings.
      b. Rated for internal pressure service at least equal to the full service pressure rating of the mating pipe.
      c. Fittings shall be at least:
         1) 3-piece for 45 degree bends.
         2) 4-piece for 90 degree bends.
7. Polyethylene flange adapters:
   a. Flange adapters shall be made with sufficient through-bore length to be clamped in a butt fusion joining machine without the use of a stub-end holder.
   b. The sealing surface of the flange adapter shall be machined with a series of small v-shaped grooves to provide gasketless sealing, or to restrain the gasket against blowout.

8. Back-up rings and flange bolts:
   a. Flange adapters shall be fitted with Type 304 or 316 stainless steel back-up rings pressure rated equal to or greater than the mating pipe.
   b. The back-up ring bore shall be chamfered or radiused to provide clearance to the flange adapter radius.
   c. Flange bolts and nuts shall be the same material as backing flange and as specified in Section 15052 - Common Work Results for General Piping.

2.03 SOURCE QUALITY CONTROL

A. HDPE piping:
   1. Manufacturer’s quality control: The pipe and fitting manufacturer shall have an established quality control program responsible for inspecting incoming and outgoing materials.
   2. Incoming polyethylene materials:
      a. Inspected for density, melt flow rate, and contamination.
      b. The cell classification properties of the material shall be certified by the supplier, and verified by manufacturer’s quality control.
      c. Approved by quality control before processing into finished goods.
   3. Outgoing materials shall be checked for:
      a. Outside diameter, wall thickness, and eccentricity in accordance with ASTM D2122 at a frequency of at least once per hour.
      b. Out of roundness at a frequency of at least once per hour.
      c. Straightness, inside and outside surface finish, markings and end cuts shall be visually inspected in accordance with ASTM F714 on every length of pipe:
         1) Quality control shall verify production checks and test for:
            a) Density in accordance with ASTM D1505 at a frequency of at least once per extrusion lot.
            b) Melt Index in accordance with ASTM D1238 at a frequency of at least once per extrusion lot.
            c) Carbon content in accordance with ASTM D1603 at a frequency of at least once per day in accordance with extrusion line.
            d) Quick burst pressure in accordance with ASTM D1599 at a frequency of at least once per day per line.
            e) Ring Tensile Strength in accordance with ASTM D2290 at a frequency of at least once per day per line.
4. Permanent records: The manufacturer shall maintain permanent QC and QA records.

5. Compliance tests:
   a. Manufacturer's inspection and testing of the materials.
      1) In case of conflict with manufacturer's certifications, the Contractor, Engineer, or Owner may request retesting by the manufacturer or have retests performed by an outside testing service.
      2) All retesting shall be at the requestor's expense, and shall be performed in accordance with this Section.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. Where not otherwise specified, install piping in accordance with ASTM F645, or manufacturer's published instructions for installation of piping, as applicable to the particular type of piping.
   2. Provide molded transition fittings for transitions from HDPE to metal or IPS pipe. Do not thread or solvent weld HDPE pipe.

B. Installation of HDPE piping:
   1. Joining:
      a. Heat fusion joining:
         1) Joints between plain end pipes and fittings shall be made by butt fusion, and joints between the main and saddle branch fittings shall be made utilizing saddle fusion employing only procedures that are recommended by the pipe and fitting manufacturer.
         2) The Contractor shall certify, in writing, that persons making heat fusion joints have received training in the manufacturer's recommended procedure and have had at least 3 years current experience in the heat fusion butt welding process.
         3) The Contractor shall maintain records of trained personnel, and shall certify that training was received not more than 12 months before commencing construction.
         4) External and internal beads shall not be removed.
      b. Heat fusion training services: The manufacturer shall provide training in the manufacturer's recommended butt fusion and saddle fusion procedures to the Contractor's installation personnel, and to the inspector(s) representing the District, prior to the start of construction.
c. Mechanical joining:
   1) Polyethylene pipe and fittings may be joined together or to other materials by means of flanged connections (flange adapters and back-up rings) or, where specifically indicated on the Drawings, flexible couplings designed for joining polyethylene pipe or for joining polyethylene pipe to another material.
   2) Flexible couplings shall be fully pressure rated and fully thrust restrained such that when installed in accordance with manufacturer's recommendations, a longitudinal load applied to the mechanical coupling will cause the pipe to yield before the mechanical coupling disjoins.

2. Installation:
   a. General:
      1) The Manufacturer shall package products for shipment in a manner suitable for safe transport by commercial carrier.
      2) When delivered, a receiving inspection shall be performed, and any shipping damage shall be reported to the Manufacturer within 7 days.
      3) Damaged pipe shall be promptly removed from the job site.
      4) Installation shall be in accordance with Manufacturer's recommendations, and this specification.
      5) Prior to making a terminal connection of each individual run of HDPE pipe, the temperature of the pipe should be allowed to approach the service temperature at which the pipe is intended to operate.
      6) All necessary precautions shall be taken to ensure a safe working environment in accordance with applicable codes and standards.
   b. Large diameter fabricated fittings: Fabricated fittings shall be butt fused to the end of a pipe.
   c. Mechanical joint and flange installation:
      1) Mechanical joints and flange connections shall be installed in accordance with the manufacturer's recommended procedure.
      2) Flange faces shall be centered and aligned to each other before assembling and tightening bolts.
      3) Every effort shall be made to ensure that the opposing faces of the flange assemblies mate up securely at a temperature approximately the same as the service temperature.
      4) In no case shall the flange bolts be used to draw the flanges into alignment.
      5) Bolt threads shall be lubricated, and flat washers shall be fitted under the flange nuts.
      6) Bolts shall be evenly tightened according to the tightening pattern and torque step recommendations of the manufacturer.
      7) At least 1 hour after initial assembly, flange connections shall be re-tightened following the tightening pattern and torque step recommendations of the manufacturer.
8) The final tightening torque shall be 100 feet-pounds or less as recommended by the manufacturer.

d. Pipe handling:
   1) Lift, move, or lower pipe and fittings only with wide fabric choker slings.
   2) Wire rope or chain shall not be used.
   3) Slings shall be of sufficient capacity for the load, and shall be inspected before use.
   4) Worn or defective equipment shall not be used.

e. Excavation, backfill material and backfilling and compacting:

3.02 FIELD QUALITY CONTROL

A. Testing:
   1. Butt fusion testing:
      a. Pipe size 14 inches and larger:
         1) The first fusion of each day shall be a trial fusion.
            a) The trial fusion shall be allowed to cool completely.
            b) Fusion test straps shall be cut out.
               (1) The test strap shall be 12 inches (minimum) or 30 times the wall thickness in length with the fusion in the center, and 1 inch (minimum) or 1.5 times the wall thickness in width.
            c) Bend the test strap until the ends of the strap touch.
         2) If the fusion fails at the joint, a new trial fusion shall be made, cooled completely and tested.
         3) Butt fusion of pipe to be installed shall not commence until a trial fusion has passed the bent strap test.
      b. Pipe size smaller than 14 inch:
         1) Test daily using ultrasonic time-of-flight diffraction (TOFD) per ISO/DIS 10863, Welding - Use of time-of-flight diffraction technique.

B. Data logging and test data:
   1. A data logger shall be installed on the fusion heated joining machine. Data on each joint shall be recorded by the data logger. Data to be recorded shall be minimum temperature of joint fusion and interface pressure of the fused joint.
   2. Recorded data from the fusion data logger and the TOFD shall be transmitted to the Owner daily.

C. Pressure testing:
   1. Test pressures as specified in Section 15052 - Common Work Results for General Piping.
   2. Temperature of test water shall be no more than 73 degrees Fahrenheit.

END OF SECTION
SECTION 15244

POLYVINYL CHLORIDE (PVC) PIPE: AWWA C900

PART 1     GENERAL

1.01 SUMMARY

A. Section includes:
   1. AWWA C905 PVC pipe and fittings.

1.02 REFERENCES

A. American Water Works Association (AWWA):
   3. C900 - Standard for Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 Inches to 60 Inches, for Water Transmission Distribution.

B. ASTM International (ASTM):

1.03 ABBREVIATIONS

A. DR: Dimension ratio.

B. NPS: Nominal pipe size followed by the size designation.

1.04 SUBMITTALS

A. Submit as specified in the General Conditions.

B. Product data: As specified in Section 15052 - Common Work Results for General Piping.
C. Shop drawings: As specified in Section 15052 - Common Work Results for General Piping.
   1. Describe materials, pipe, fittings, and gaskets.
   2. Manufacturer’s product handling and installation instructions.

1.05 QUALITY ASSURANCE

A. Mark plastic pipe with date of extrusion, nominal size, class, manufacturer and all markings required in accordance with ASTM and AWWA standards.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Protect from sunlight, scoring, and distortion.

B. Do not allow surface temperatures to exceed 120 degrees Fahrenheit.

C. Deliver, offload, handle, and store pipe in accordance with manufacturer’s or pipe supplier’s recommendations and best practices provided by AWWA M23 and AWWA C605, including compliance with minimum recommended bending radius and maximum safe pulling forces for each specific pipe.

PART 2 PRODUCTS

2.01 PIPE

A. General:
   1. Extruding and molding material: Virgin material containing no scrap, regrind, or rework material except where permitted in the referenced standards.
   2. In accordance with AWWA C900.
   3. Made from a PVC compound conforming to cell classification 12454 in accordance with ASTM D1784.

B. Pipe:
   1. Bell and spigot:
      a. Pipe with integral bell.
      b. Pressure Class as scheduled in Section 15052 - Common Work Results for General Piping with a minimum DR of 25.
      c. Manufacturers: One of the following or equal:
         1) Diamond Plastics Corp.
         2) CertainTeed.
         3) North American Pipe Corp.
2.02 FITTINGS

A. Material:
   1. Cast or ductile iron fittings as specified in Section 15211 - Ductile Iron Pipe: AWWA C151, sized for the dimensions of the pipe being used.

B. Equal to or greater pressure rating than the pipe.

2.03 JOINTS

A. Bell and spigot joints:
   1. Push-on or mechanical joint type as identified in the Piping Schedule in Section 15052 - Common Work Results for General Piping.
   2. Gasketed joint assembly: Meet or exceed the requirements in accordance with ASTM D3139.
   3. Factory installed gaskets: EPDM in accordance with ASTM F477.
   4. Joint restraint at fittings:
      a. Concrete thrust blocks:
         1) Install thrust blocks at all changes in pipe diameter and at all fittings.
         2) Design thrust blocks for both test and peak operating pressures.
      b. Push-on joint restraint harnesses:
         1) Manufacturers: One of the following or approved equal:
            a) EBAA Iron, Inc.:
               (1) For pipes 4 to 12-inch: Series 1500.
               (2) For pipes 14 to 48-inch: Series 2800.
            b) Star Pipe Products, Series 4100P.
            c) Sigma Corp., PV-Lok Model PWP.
         2) Materials:
            a) Restraint and backup rings: Ductile iron in accordance with ASTM A536.
            b) Wedge and wedge actuating components: Ductile iron in accordance with ASTM A536.
            c) Tie rods: Low alloy steel in accordance with AWWA C111.
         3) Coatings:
            a) Provide manufacturer applied coating system.
            b) Manufacturers: One of the following or equal:
               (1) EBAA Iron Inc., Mega-Bond.
               (2) Star Pipe Products, Star-Bond.
               (3) Sigma Corp., Corrsafe™ Electro-deposition coating.
         4) Consist of a backup ring behind the PVC bell and a restraint ring consisting of multiple gripping wedges connected with number and type of tie rods as recommended by the manufacturer.
         5) Allow post assembly angular deflection that is a minimum of 50 percent of the angular deflection allowed by the push-on joint.
         6) Pressure rating equal to or greater than that of the pipe on which it is being used and a minimum safety factor of 2:1 for all sizes.
2.04 SOURCE QUALITY CONTROL

A. Bell and spigot piping:
   1. Hydrostatic proof testing in accordance with AWWA C900: Test pipe and integral bell to withstand, without failure, 2 times the pressure class of the pipe for a minimum of 5 seconds.
   2. Hydrostatic proof testing in accordance with AWWA C905: Test pipe and integral bell to withstand, without failure, 2 times the pressure class of the pipe for a minimum of 5 seconds.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. Install piping in accordance with ASTM F645, AWWA C605, and manufacturer’s or pipe supplier’s published installation instructions.
   2. For open cut installations, install underground warning tape as specified in Section 15076 - Pipe Identification.
   3. Install pipe with tracer wire per EMWD Std Dwg B656.

B. Tapping:
   1. Saddle tapping:
      a. Saddle taps are allowable on all sizes and classes of AWWA C900 pipe.
      b. 2-inch is the maximum allowable outlet size for performing a saddle tap.
      c. As specified in Section 15120 - Piping Specialties for allowable service saddles.
   2. Tapping sleeves:
      a. Tapping sleeves are allowable on all sizes and classes of PVC AWWA C900.
      b. As specified in Section 15120 - Piping Specialties for allowable tapping sleeves.

3.02 FIELD QUALITY CONTROL

A. Leakage test for piping:
   1. Subject to visible leak test and pressure test with maximum leakage allowance, as specified in Section 15956 - Piping Systems Testing.
   2. Pressure test with maximum leakage allowance.
      a. Perform test after placing sufficient backfill.
      b. In areas requiring immediate backfill, test prior to placement of permanent surfacing.
      c. Test pressure: As specified in the Piping Schedule in Section 15052 - Common Work Results for General Piping.
      d. No leakage is allowed for FPVCP.

END OF SECTION
SECTION 15249
POLYVINYL CHLORIDE (PVC) PIPE: SCHEDULE TYPE

PART 1   GENERAL

1.01  SUMMARY

A. Section includes: Schedule type PVC pipe and fittings.

1.02  REFERENCES

A. ASTM International (ASTM):

1.03  SUBMITTALS

A. Submit as specified in General Conditions.

B. Product data: As specified in Section 15052 - Common Work Results for General Piping.

1.04  DELIVERY, STORAGE, AND HANDLING

A. Protect from sunlight, scoring, and distortion.

B. Do not allow surface temperatures to exceed 120 degrees Fahrenheit.

C. Store and handle as recommended by manufacturer in published instructions.
PART 2  PRODUCTS

2.01  MATERIALS

A. Extruding and molding material: Virgin material containing no scrap, regrind, or rework material except where permitted in the referenced standards.
   1. Pipe: Designation PVC 1120 in accordance with ASTM D1785 and appendices:
      a. Extruded from Type I, Grade 1, Class 12454-B material in accordance with ASTM D1784.
      b. Schedule 80 unless otherwise indicated on the Drawings or specified in the Piping Schedule in Section 15052 - Common Work Results for General Piping.
   2. Fittings: In accordance with ASTM D2467.
      a. Same material as the pipe and of equal or greater pressure rating.
      b. Supplied by pipe manufacturer.
      c. Unions 2-1/2 inches and smaller:
         1) Use socket end screwed unions.
      d. Unions 3 inches and larger:
         1) Use socket flanges with 1/8-inch full-face soft neoprene gasket.
   3. Solvent cement:
      a. In accordance with ASTM D2564.
      b. Manufacturers: The following or equal:
         1) IPS Corp.
      c. Certified by the manufacturer for the service of the pipe.
      d. In potable water applications: Provide solvent cement listed by NSF for potable water applications.
      e. Primer: As recommended by the solvent cement manufacturer.

2.02  SOURCE QUALITY CONTROL

A. Meets or exceeds all quality assurance test requirements stated in ASTM D1785.

PART 3  EXECUTION

3.01  INSTALLATION

A. Install piping in accordance with ASTM F645, or manufacturer's published instructions for installation of piping, as applicable.

B. Provide molded transition fittings for transitions from plastic to metal pipe.
   1. Do not thread pipe.

C. Locate unions where indicated on the Drawings, and elsewhere where required for adequate access and assembly of the piping system.

D. Provide serrated nipples for transition from pipe to rubber hose.
E. Solvent weld joints in accordance with ASTM D2855.

3.02 FIELD QUALITY CONTROL

A. Test pipe as specified in Section 15052 - Common Work Results for General Piping and Section 15956 - Piping Systems Testing.

END OF SECTION
SECTION 15278

STEEL PIPE

PART 1     GENERAL

1.01 SUMMARY

A. Section includes: Steel piping, joints, fittings, pipe lining and coating, and fabricated steel piping fittings and specials.

1.02 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO):

B. American Society of Mechanical Engineers (ASME):
   3. B16.5 - Pipe Flanges and Flanged Fittings.

C. American Water Works Association (AWWA):
   1. C200 - Steel Water Pipe 6 Inches and Larger.
   4. C206 - Field Welding of Steel Water Pipe.

D. ASTM International (ASTM):

E. NACE International (NACE):
   1. RP0274-74 - Standard Recommended Practice.

1.03 SYSTEM DESCRIPTION

A. Design requirements:
   1. Design criteria for pipe and pipe fittings: In accordance with AWWA Manual M11 with the following modifications:
      a. Wall thickness: As designed or minimum 1/4 inch for pipe from 12 inches in diameter to, and including, 72 inches in diameter.
      b. Inside diameter of unlined pipe: Nominal.
      c. Inside diameter of lined pipe: As measured from face to face of liner, but not less than nominal.
      d. Deflection of underground pipe inside diameter: Maximum 2 percent under trench load of AASHTO Standard Specifications for Highway Bridges, H-20 vehicle loading.
      e. Working stress of steel: Maximum 50 percent of yield stress.
      f. Contractor shall develop and submit calculations to determine the steel pipe and fitting wall thickness and design requirements according to the requirements of this specification.
1.04 SUBMITTALS

A. Submit as specified in General Conditions.

B. Product data: As specified in Section 15052 - Common Work Results for General Piping.

C. Shop drawings:
   1. Details of fittings and specials showing thickness and dimensions of plates.
   2. Detail of welds and materials.
   3. Tabulated layout schedules for cement-mortar lined and coated steel pipe.
   4. Details of fittings and specials showing thickness and dimensions of plates.
   5. Design calculations:
      a. Wall thicknesses for external loading, special loading, and internal pressure.

A. Calculations:
   1. Submit calculations prepared and stamped by a professional engineer licensed in the State of California.

1.05 QUALITY ASSURANCE

A. Applicable standards:
   1. Cement-mortar lined and coated steel pipe shall conform to the following standards, as complemented and modified in this Section:
      b. Cement-mortar lining and coating: AWWA C205.
      c. Fittings and specials: AWWA C208.
      d. Reinforcement of fittings and specials: AWWA M11.

PART 2 PRODUCTS

2.01 MATERIALS

A. Steel pipe:
   1. Type, larger than 12 inches: AWWA C200, without butt strap, riveted, or swaged joints; wall thickness as specified.

B. Steel pipe fittings:
   1. Flanged fittings:
      a. Type for 12-inch and smaller pipe: ASME B16.1, cast iron or ductile iron, 125 pounds; or ASME B16.5, steel, 150 pounds, galvanized in accordance with ASTM A153 where used with galvanized pipe.
      b. Type for larger than 12-inch pipe: ASME B16.5, steel, 150 pounds; galvanized in accordance with ASTM A153 where used with galvanized
pipe; or AWWA C207 and AWWA C208, fabricated from flanges and steel pipe, respectively.

c. Companion flanges for 4 inches and smaller pipe: ASME B16.1, cast iron or ductile iron, 125 pounds; ASME B16.5, steel, 150 pounds, slip-on or welding neck; or ammonia type for use on chlorine liquid or gas piping.

d. Companion flanges for larger than 4 inch to and including 12-inch pipe: ASME B16.5, slip-on or welding neck type.

e. Companion flanges for larger than 12-inch pipe: ASME B16.5, steel, 150 pounds; galvanized in accordance with ASTM A153 where used with galvanized pipe; or AWWA C207, steel plate or raised hub type.

f. Weld flanges to pipe or fittings before applying lining.

g. Machine flanges or provide tapered filler for changes in grade or to slope lines for drainage.

h. Flange bolts: As specified in Section 15052 - Common Work Results for General Piping.

i. Gaskets: As specified in Section 15052 - Common Work Results for General Piping.

2. Welding fittings:

a. Welding fittings for piping 8 inches and less in nominal diameter: Butt-welding fittings in accordance with ASME B16.9, standard wall, or standard weight.

b. Welding fittings for piping larger than 8 inches in nominal diameter: Butt-welding fittings in accordance with ASME B16.9, or, at the option of the Contractor, made up out of sections of pipe welded together, except where smooth bends are indicated for air lines.

c. Fittings made up of sections of pipe welded together shall be made of pipe of at least the same wall thickness as the pipe with which used, and bends shall be miter bends, fabricated in accordance with AWWA C208 and as supplemented by AWWA Manual M11. Welding of these made-up fittings shall be in accordance with AWWA C206.

1) Design and fabricate outlets and 4 branch fittings in accordance with AWWA Manual M11.

2) Bends may be welded to adjacent pipe sections.

   a) Bends shall be manufactured of the following number of pieces:
      (1) Bends from 0 to 30 degrees angle, 2 pieces.
      (2) Bends from 30 to 45 degrees angle, 3 pieces.
      (3) Bends from 45 to 67-1/2 degrees angle, 4 pieces.
      (4) Bends from 67-1/2 to 90 degrees angle, 5 pieces.

C. Steel pipe lining and coating:

1. General:

   a. Except where otherwise specified in the Specifications and indicated on the Drawings, lining and coating for steel pipe shall be as specified.
b. Pipe coating:
   1) Except as otherwise specified or indicated on the Drawings, provide underground steel piping with one of the coatings specified.
   2) Extend pipe coating for underground piping 6 inches above finish grade or finish floor, and neatly terminate.
   3) Field paint aboveground steel pipe as specified in Execution of this Section.

2. Cement-mortar lining and coating:
   a. Lining:
      1) Shop apply cement-mortar lining for steel pipe, interior, in accordance with AWWA C205; or, at the option of Contractor, field apply with a pipe lining machine.
   b. Coating:
      1) Cement-mortar coating for steel pipe exterior: In accordance with AWWA C205, modified as follows:
         a) Portland cement: ASTM C150, Type II, low alkali.
         b) Sand: AWWA C205 except that the total percentage of deleterious material shall not exceed 3 percent.

D. Fabricated steel piping fittings and specials:
   1. General: Specified in this Section are the design and fabrication of fabricated steel piping fittings and specials, which include elbows, branches, nozzles, manifolds, headers, heads, collars, stiffeners, reinforcements, and other steel fabrications relating to steel piping, but shall not include steel pipe.
   2. Design:
      a. Contractor shall design and detail fittings and specials:
         1) Design: In accordance with the recommended procedures in AWWA Manual M11, as complemented and modified in this Section.
         3) Design reinforcing for fittings and specials for the specified test pressure.
         4) Fittings shall conform in dimension to AWWA C208, complemented with the provisions specified in this Section.
         5) The working stress for steel used for fabrication of pipe shall not exceed 50 percent of the yield stress.
      b. The thickness of pipe, large elbows, and headers, except header nozzles, shall be the thicker of:
         1) The thickness designed in accordance with the design methods specified in the preceding paragraph “Fabricated Steel Piping Fittings and Specials.”
         2) The thickness indicated on the Drawings.
         3) The following thicknesses:
            a) For pipes smaller than 72 inches in diameter: Minimum 1/4 inch.
c. Elbows shall be of the number of pieces specified under paragraph Steel Pipe Fittings, “Welding and Fittings”, and thickness of material shall conform to thickness of pipe or manifold shells specified.

d. Ends of fittings to be welded to pipe shall be beveled for welding.

3. Fabrication:
   a. Shop fabricate steel piping fittings and specials in units as long as practicable for safe hauling and installation. Minimize number of field welds.
   b. Fabricate fittings and specials to uniform lengths with proper end clearance for the specified types of joint or attachment.
   c. Fabricate fittings and specials to allow field assembly without cutting or special work.
   d. Where specified in the Piping Schedule in Section 15052 - Common Work Results for General Piping or indicated on the Drawings, the inside of fabricated steel manifolds and other fittings and specials shall receive a cement-mortar lining in accordance with AWWA C205.
      1) Reinforce lining for piping 24 inches in diameter and larger with wire fabric.
   e. Do not weld flanges to nozzles until the nozzles and reinforcements are completely welded to the header.
      1) Accurately space and align flanges so that when connections have been made there will be no stress on the header, piping, or equipment. Properly locate and align equipment.

4. Dished heads:
   a. Dished heads on 84 inch diameter and smaller manifolds: 1 piece (seamless) spherically dished (torispherical) heads.
      1) Larger heads may be seamed.
   b. Dish radius: Same dimension as the outside diameter of the head measured at skirt.
   c. Skirt face length: Not less than 3 inches.
   d. Design heads in accordance with recommended practice in AWWA M11, Steel Pipe Manual.

5. Testing: No shop testing will be required for manifolds or piping connected thereto.

E. Steel pipe, cement-mortar lined and coated:
   1. General:
      a. Applicable standards: Cement-mortar lined and coated steel pipe shall conform to the standards specified in General of this Section.
      b. Identification marks: Provide identification marks in accordance with AWWA C200. These marks shall be stenciled or otherwise shown at the top of the piping items exterior, including the following information:
         1) Name or trademark of the manufacturer.
         2) Date of manufacture of the item.
         3) Internal diameter in inches.
4) Number of the item, sequential from initial to end station.
c. Diameter designation: The pipe diameter specified in the Specifications and indicated on the Drawings shall be the clear inside diameter after application of the cement-mortar lining with a tolerance of plus 0 inch and minus 1/4 inch.

2. Design:
   a. Pipe and fittings shall be designed by Contractor.
   b. Design: In accordance with the recommended procedures in AWWA Manual M11, as complemented and modified in this Section.
   c. Thicknesses of Pipe, Fittings and Specials shall be the thicker of:
      1) The thickness designed in accordance with the design methods specified in the preceding subparagraph below.
      2) The thickness indicated on the Drawings.
      3) The following thicknesses:
         a) For pipes 26 inches and less in nominal diameter, not less than 1/4-inch.
         b) For pipes more than 26 inches and less than 38 inches in nominal diameter, not less than 5/16 inch.
         c) For pipes 38 inches to and including 54 inches in nominal diameter, not less than 3/8-inch.
   d. The working stress for steel used for fabrication of pipe shall not exceed 50 percent of the yield stress.
   e. Break longitudinal and girth seams for straight seam pipe shall be no greater in number than would be required for the fabrication of pipe with 96-inch by 120-inch steel plates.
      1) Break longitudinal seams at the girth seams.
   f. Calculate earth loads using the following formula:

\[
W = 120 \text{ (lb/ft}^3) \times H \times B
\]

wherein the various terms shall have the following meaning:

\[
W: \text{ Earth load, pounds per linear foot of pipe.}
H: \text{ Height of fill over the pipe, feet.}
B: \text{ Outside diameter of the pipe, feet.}
x: \text{ Mathematical symbol for multiplication.}
\]

g. Add AASHTO Standard Specifications for Highway Bridges, H-20 vehicle loading to earth loads.
h. Design pipe, fittings and specials for a deflection, under external loads, not to exceed 2 percent of the diameter.
   1) Stiffness computations shall not consider the effect of the cement-mortar lining and coating.
2) Calculate deflection using the Spangler formula and the following values:
   a) Bedding constant $K = 0.100$.
   b) Modulus of soil reaction $E' = 700$ pounds per square inch.
   c) Deflection lag constant $D_1 = 1.00$.

   i. Where piping is designated to be flanged or welded in order to restrain thrust, the design of the cylinder and flange or welded joint shall take into account the effect of stresses caused by thrust loads.

   j. Steel cylinder shall be subject to no more than the lesser of 15,000 pounds per square inch or 50 percent of the steel yield stress.

3. Materials:
   a. Cement: ASTM C150, Type II, low alkali.
   b. Gaskets shall be as specified in Section 15052 - Common Work Results for General Piping and meet the following requirements:
      1) Minimum tensile strength, tested in accordance with ASTM D412, between 2,000 and 2,700 pounds per square inch.
      2) Minimum elongation, tested in accordance with ASTM D412, between 350 and 400 percent.
      3) Shore A durometer hardness, tested in accordance with ASTM D2240, between 50 and 65.
      4) Specific gravity, tested in accordance with ASTM D297, between 0.90 and 1.50.
      5) Maximum compression set, tested in accordance with Method B of ASTM D395, 20 percent.
      6) Maximum tension strength loss, tested in accordance with ASTM D573 at 96 hours, 70 degrees Centigrade, in air, 20 percent.
      7) Maximum elongation loss, tested in accordance with ASTM D573 at 96 hours, 70 degrees Centigrade, in air, 20 percent.
      8) Maximum absorption, tested in accordance with ASTM D471 at 48 hours, 70 degrees Centigrade, in air, 5 percent.

4. Fabrication:
   a. Joints: Except as otherwise specified or indicated on the Drawings, provide bell and spigot type joints with rubber gaskets.
      1) Bell and spigot rings: Rolled Carnegie shape M-3516.
   b. Flanges: AWWA C207, Class D, steel ring, and as follows:
      1) Match pipe flanges to the valve flanges.
         a) At flanged joints connecting to valves, provide a steel pipe section without rod reinforcing and not less than 24 inches in length.
         b) Apply cement-mortar lining and coating to the steel pipe section.
   c. Shop coat of primer: Flanges and portions of pipe not covered with cement-mortar shall be given a shop coating of primer.
   d. Bend radii of fittings: Not less than 2.5 times the nominal diameter.
PART 3 EXECUTION

3.01 INSTALLATION

A. Joints:
   1. Steel pipe joints shall be screwed, welded, flanged, grooved, or made with flexible joints. The type of joint for piping is specified in the Piping Schedule in Section 15052 - Common Work Results for General Piping.
   2. In addition to the joints indicated on the Drawings, provide unions, flexible couplings, flanged joints, and other types of joints or means necessary to allow ready assembly and disassembly of the piping.
   3. Unless otherwise indicated on the Drawings or specified in the Piping Schedule in Section 15052 - Common Work Results for General Piping, pipe joints shall be as follows:
      a. Pipe larger than 4 inches in nominal diameter shall have flanged joints, welded joints, or joints made with flexible couplings.

B. Flanged joints:
   1. In flanged joints, flanges shall come together at the proper orientation with no air gaps between the flanges after the gaskets are in place.
   2. Attach slip-on flanges to pipe by 2 fillet welds, in accordance with AWWA C207.
   3. Secure welding neck flanges with full penetration butt welds without backing rings.
      a. After welding in place, the faces of flanges shall be perpendicular to the axis of the pipe, or, in the case of fittings, at the proper angle to each other, and bolt holes shall be in proper alignment.

C. Welded joints:
   1. Welded joints shall be electric welded in accordance with AWWA C206.
   2. Welders shall be qualified pursuant to the provisions of AWWA C206.
      a. Welders' testing shall be at the Contractor's expense, including cost of test nipples, welding rods, and equipment.
   3. Do not weld galvanized pipe.

D. Lining and coating:
   1. Field paint aboveground steel pipe as specified in Section 09960 - High-Performance Coatings.
   2. Field applied cement-mortar lining shall be of the same density, smoothness, and thickness as shop applied lining, and in accordance to applicable portions of AWWA C602.
   3. Plastic tape wrap application procedures shall be in accordance with manufacturer's published instructions.
      a. Apply primer with brush, without runs and drips.
      b. Lap wrapping not less than 1/2-inch. A single wrap lapped 50 percent or more will not be acceptable.
c. Application on welded joints:
   1) Remove sharp edges of weld spatter and slag with a file or ball peen hammer before wrapping welded joints.
   2) Apply a single thickness of tape base wrap over the primer, around the weld.
   3) Start first wrapping 4 inches back on the pipe wrap, spiral wrap tape over the joint holding the proper tension and overlap, and finish 4 inches back on the pipe wrap on the other side of the joint.
   4) Apply final wrapping in same manner.

d. Wrap fittings, valves, and other odd shaped components in the pipeline with first and finish wrapping over the prime coat.

e. Wrap joints, fittings, valves, and other irregular shapes of piping with extruded coatings with tape as specified in this subparagraph.

4. Protect lining of fabricated steel piping fittings and specials during hauling, installation, and operation.

5. Finish joints of fabricated steel piping fittings and specials as specified for pipe lining after field welding is done.

6. After final field welding of fabricated steel piping fittings and specials, complete the lining and exterior painting at and near the welded connections.
   a. Repair or replace lining damaged as a result of welding heat, handling, or other causes.

3.02 FIELD QUALITY CONTROL

A. Testing: Fabricated steel manifolds shall be field tested with the pipe to which they connect.

B. Holiday detection testing of plastic tape wrap coatings:
   1. Perform a complete high voltage electrical inspection (holiday detection testing) of all steel piping systems and fittings coated with plastic tape wrap prior to burying.
      a. Perform high voltage electrical inspection in strict accordance with NACE RP0274-74.
      b. Test voltage used for the electrical inspection of the piping and fittings shall be in accordance with the recommendations given by the tape coating manufacturer in their published literature.
      c. Repair all holidays and defects found in the coating system through the high voltage electrical inspection in strict accordance with the tape coating manufacturer's recommendations.
      d. Retest repaired areas in the coating prior to burial of the piping to ensure that all holidays and defects in the coating have been properly repaired.
   2. Before conducting holiday detection testing on any piping systems, submit to Engineer for review and approval technical literature and data describing the
testing instrumentation, equipment, electrodes, and other accessories that will be used.

a. Literature and data shall include complete information covering operation and use of the testing equipment, including operational voltage ranges.

3. All holiday detection testing and coating repair work shall be witnessed, inspected and approved by the Engineer.

C. Holiday detection testing of extruded coatings:
   1. Perform a complete high voltage electrical inspection (holiday detection testing) of all steel piping systems and fittings coated with extruded high-density polyethylene prior to burial of the pipe.
   2. Perform the high voltage electrical testing as specified under the preceding paragraph “Holiday Detection Testing of Plastic Tape Wrap Coatings.”

END OF SECTION
SECTION 15956

PIPING SYSTEMS TESTING

PART 1  GENERAL

1.01  SUMMARY

A. Section Includes: Test requirements for piping systems.

B. Refer to Division 2 of Detailed Provisions of EMWD Specifications (Section IV) for additional requirements. In case of a conflict, more stringent requirements shall govern.

1.02  REFERENCES

A. Uniform Plumbing Code (UPC).

B. American National Standards Institute/American Society of Mechanical Engineers (ANSI/ASME):
   1. B31.3 - Process Piping.

C. Uniform Mechanical Code (UMC).

1.03  TESTING REQUIREMENTS

A. General Requirements:
   1. Testing requirements are stipulated in Laws and Regulations, are included in the Piping Schedule in Section 15052 - Common Work Results for General Piping; are specified in the Specifications covering the various types of piping, and are specified herein.
   2. Requirements in Laws and Regulations supersede other requirements of Contract Documents, except where requirements of Contract Documents are more stringent, including higher test pressures, longer test times, and lower leakage allowances.
   3. Test plumbing piping in accordance with Laws and Regulations, the Uniform Plumbing Code, and UL requirements.
   4. Lower test pressure as necessary to prevent testing the lowest point above a safe test pressure.

B. Furnish necessary personnel, materials, and equipment, including bulkheads, restraints, anchors, temporary connections, pumps, water, pressure gauges, and other means and facilities required to perform tests.
C. Water for testing and cleaning:
   1. Water for testing and cleaning will be provided as specified in Section 01500 - Temporary Facilities and Controls.

D. Pipes to be tested: Test only those portions of pipes that have been installed as part of this Contract. Test new pipe sections prior to making final connections to existing piping. Furnish and install test plugs, bulkheads, and restraints required to isolate new pipe sections. Do not use existing valves as test plug or bulkhead.

E. Unsuccessful tests:
   1. Where tests are not successful, correct defects or remove defective piping and appurtenances and install piping and appurtenances that comply with the specified requirements.
   2. Repeat testing until tests are successful.

F. Test completion: Drain and leave piping clean after successful testing.

G. Test water disposal: Dispose of testing water in accordance with requirements of federal, state, county, and city regulations governing disposal of wastes in the location of the Project and disposal site.

1.04 SUBMITTALS

A. Submit as specified in the General Conditions.

B. Schedule and notification of tests:
   1. Submit a list of scheduled piping tests by noon of the working day preceding the date of the scheduled tests.
   2. Notification of Readiness to Test: Immediately before testing, notify Engineer in writing of readiness, not just intention, to test piping. Have personnel, materials, and equipment specified in place before submitting notification of readiness.

1.05 SEQUENCE

A. Clean piping before pressure or leak tests.

B. Test gravity piping underground, including sanitary sewers, for visible leaks before backfilling and compacting.

C. Underground pressure piping may be tested before or after backfilling when not indicated or specified otherwise.

D. Backfill and compact trench, or provide blocking that prevents pipe movement before testing underground piping with a maximum leakage allowance.
E. Test underground piping before encasing piping in concrete or covering piping with slab, structure, or permanent improvement.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 TESTING ALIGNMENT, GRADE, AND DEFLECTION

A. Alignment and grade:
   1. Visually inspect the interior of gravity piping with artificial light, reflected light, or laser beam.
   2. Consider inspection complete when no broken or collapsed piping, no open or poorly made joints, no grade changes that affect the piping capacity, or no other defects are observed.

3.02 TESTING GRAVITY FLOW PIPING

A. Test gravity flow piping indicated with "GR" in the Piping Schedule, as follows:
   1. Unless specified otherwise, subject gravity flow piping to the following tests:
      a. Alignment and grade.
      b. For plastic piping test for deflection.
      c. Visible leaks and pressure with maximum leakage allowance, except for storm drains and culverts.
   2. Inspect piping for visible leaks before backfilling. Provide temporary restraints when needed to prevent movement of piping. Pressure test piping with maximum leakage allowance after backfilling.
   3. With the lower end plugged, fill piping slowly with water while allowing air to escape from high points. Keep piping full under a slight head of water for at least 24 hours.
      a. Examine piping for visible leaks. Consider examination complete when no visible leaks are observed.
      b. Maintain piping with water or allow a new water absorption period of 24 hours for the performance of the pressure test with maximum leakage allowance.
      c. After successful completion of the test for visible leaks and after the piping has been restrained and backfilled, subject piping to the test pressure for a minimum of 4 hours while accurately measuring the volume of water added to maintain the test pressure.
         1) For polyvinyl chloride (PVC) gravity sewer pipe: 25 gallons per day per inch diameter per mile of piping under test.
3.03 TESTING HIGH-HEAD PRESSURE PIPING

A. Test piping for which the specified test pressure in the Piping Schedule is 20 pounds per square inch gauge or greater, by the high-head pressure test method, indicated "HH" in the Piping Schedule.

B. General:
1. Test connections, hydrants, valves, blowoffs, and closure pieces with the piping.
2. Do not use installed valves for shutoff when the specified test pressure exceeds the valve's maximum allowable seat differential pressure. Provide blinds or other means to isolate test sections.
3. Do not include valves, equipment, or piping specialties in test sections if test pressure exceeds the valve, equipment, or piping specialty safe test pressure allowed by the item's manufacturer.
4. During the performance of the tests, test pressure shall not vary more than plus or minus 5 pounds per square inch gauge with respect to the specified test pressure.
5. Select the limits of testing to sections of piping. Select sections that have the same piping material and test pressure.
6. When test results indicate failure of selected sections, limit tests to piping:
   a. Between valves.
   b. Between a valve and the end of the piping.
   c. Less than 500 feet long.
7. Test piping for minimum 2 hours for visible leaks test and minimum 2 hours for the pressure test with maximum leakage allowance.

C. Testing procedures:
1. Fill piping section under test slowly with water while venting air. Use potable water for all potable waterlines and where noted on the Piping Schedule.
2. Before pressurizing for the tests, retain water in piping under slight pressure for a water absorption period of a minimum of 24 hours.
3. Raise pressure to the specified test pressure and inspect piping visually for leaks. Consider visible leakage testing complete when no visible leaks are observed.

D. Pressure test with maximum leakage allowance:
1. Leakage allowance is zero for piping systems using flanged, National Pipe Thread threaded and welded joints.
2. Pressure test piping after completion of visible leaks test.
3. For piping systems using joint designs other than flanged threaded or welded joints, accurately measure the makeup water necessary to maintain the pressure in the piping section under test during the pressure-test period.
   a. Consider the pressure test to be complete when make-up water added is less than the allowable leakage and no damage to piping and appurtenances has occurred.
b. Successful completion of the pressure test with maximum leakage allowance shall have been achieved when the observed leakage during the test period is equal or less than the allowable leakage and no damage to piping and appurtenances has occurred.

c. When leakage is allowed, calculate the allowable leakage by the following formula:

\[ L = S \times D \times P^{1/2} \times 133,200^{-1} \]

wherein the terms shall mean:

- \( L \) = Allowable leakage in gallons per hour.
- \( S \) = Length of the test section in feet.
- \( D \) = Nominal diameter of the piping in inches.
- \( P \) = Average observed test pressure in pounds per square inch, gauge, at the lowest point of the test section, corrected for elevation of the pressure gauge.
- \( x \) = The multiplication symbol.

### 3.04 TESTING LOW-HEAD PRESSURE PIPING

A. Test piping for which the specified test pressure is less than 20 pounds per square inch gauge, by the low-head pressure test method, indicated "LH" in the Piping Schedule.

B. General:

1. Test pressures shall be as scheduled in Section 15052 - Common Work Results for General Piping.
2. During the performance of the tests, test pressure shall not vary more than plus or minus 2 pounds per square inch gauge with respect to the specified test pressure.
3. Test connections, blowoffs, vents, closure pieces, and joints into structures, including existing bell rings and other appurtenances, with the piping.
4. Test piping for a minimum of 2 hours for visible leaks test and a minimum of 2 hours for the pressure test with maximum leakage allowance.

C. Visible leaks test:

1. Subject piping under test to the specified pressure measured at the lowest end.
2. Fill piping section under test slowly with potable water while venting air.
3. Before pressurizing for the tests, retain water in piping under slight pressure for the water absorption period of a minimum of 24 hours.
4. Raise pressure to the specified test pressure and inspect piping visually for leaks. Consider testing complete when no visible leaks are observed.

D. Pressure test with maximum leakage allowance:
   1. Pressure test piping after completion of visible leaks test.
   2. Accurately measure the makeup water necessary to maintain the pressure in the piping section under test during the pressure test period.
      a. Consider the pressure test to be complete when make-up water added is less than the allowable leakage of 80 gallons per inch of nominal diameter, per mile of piping section under test after 24 hours and no damage to piping and appurtenances has occurred.
      b. Successful completion of the leakage test shall have been achieved when the observed leakage is equal to or less than the allowable leakage and no damage to piping and appurtenances has occurred.

E. Optional joint test:
   1. When joint testing is allowed by note in the Piping Schedule, the procedure shall be as follows:
      a. Joint testing will be allowed only for low-head pressure piping.
   2. Joint testing may be performed with water or air.
   3. Joint test piping after completion of backfill and compaction to the top of the trench.
   4. Joint testing with water:
      a. Measure test pressure at the invert of the pipe. Apply pressure of 4 feet plus the inside diameter of the pipe in the water column within 0.20 foot in the water column.
      b. Maintain test pressure for 1 minute.
      c. Base the allowable leakage per joint on 80 gallons per inch nominal diameter per mile of piping per 24 hours equally distributed to the actual number of joints per mile for the type of piping.
      d. Consider the pressure test to be complete when makeup water added is less than the allowable leakage.
      e. Successful completion of the joint test with water shall have been achieved when the observed leakage is equal to or less than the allowable leakage.
   5. Joint testing with air:
      a. Apply test pressure of 3 pounds per square inch gauge with a maximum variation of plus 0.20 and minus 0.00 pounds per square inch.
      b. Maintain test pressure for 2 minutes.
      c. Consider the pressure test to be complete when the test pressure does not drop below 2.7 pounds per square inch for the duration of the test.

END OF SECTION
SECTION 15958
MECHANICAL EQUIPMENT TESTING

PART 1  GENERAL

1.01  SUMMARY
A. Section includes: Testing of mechanical equipment and systems.

1.02  REFERENCES
A. American National Standards Institute (ANSI):
   1. S1.4 Specification for Sound Level Meters.

B. Hydraulic Institute (HI).

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

1.03  SUBMITTALS
A. Project closeout documents:

PART 2  PRODUCTS

Not Used.

PART 3  EXECUTION

3.01  GENERAL
A. Commissioning of equipment as specified in:
   1. This Section.
   2. Section 01756 - Commissioning.
   3. Equipment sections:
      a. If testing requirements are not specified, provide Level 1 Tests.

B. Test and prepare piping as specified in Section 15956 - Piping Systems Testing.

C. Operation of related existing equipment:
   1. District will operate related existing equipment or facilities necessary to accomplish the testing.
2. Schedule and coordinate testing as required by Section 01756 - Commissioning.

D. Provide necessary test instrumentation that has been calibrated within 1 year from date of test to recognized test standards traceable to the NIST or approved source.
   1. Properly calibrated field instrumentation permanently installed as a part of the Work may be utilized for tests.
   2. Prior to testing, provide signed and dated certificates of calibration for test instrumentation and equipment.

E. Test measurement and result accuracy:
   1. Use test instruments with accuracies as recommended in the appropriate referenced standards. When no accuracy is recommended in the referenced standard, use 1 percent or better accuracy test instruments.
      a. Improved (lower error tolerance) accuracies specified elsewhere prevail over this general requirement.
   2. Do not adjust results of tests for instrumentation accuracy.
      a. Measured values and values directly calculated from measured values shall be the basis for comparing actual equipment performance to specified requirements.

3.02 PUMP TESTS, ALL LEVELS OF TESTING

A. Test in accordance with the following:
   1. Applicable HI Standards.
   2. This Section.
   3. Equipment sections.

B. Test tolerances: In accordance with appropriate HI Standards, except the following modified tolerances apply:
   1. From 0 to plus 5 percent of head at the specified flows.
   2. From 0 to plus 5 percent of flow at the rated design point head.
   3. No negative tolerance for the efficiency at the specified flows.
   4. No positive tolerance for vibration limits. Vibration limits and test methods in HI Standards do not apply, use limits and methods specified in this or other Sections of the Specifications.

3.03 DRIVERS TESTS

A. Test motors as specified in Section 16222 - Low Voltage Motors up to 500 Horsepower.

B. Test other drivers as specified in the equipment section.

3.04 NOISE REQUIREMENTS AND CONTROL

A. Perform noise tests in conjunction with vibration test analysis.
B. Make measurements in relation to reference pressure of 0.0002 microbar.

C. Make measurements of emitted noise levels on sound level meter meeting or exceeding ANSI S1.4, Type II.

D. Set sound level meter to slow response.

E. Unless otherwise specified, maximum free field noise level not to exceed 85 dBA measured as sound pressure level at 3 feet from the equipment.

3.05 PRESSURE TESTING

A. Hydrostatically pressure test pressure containing parts at the appropriate standard or code required level above the equipment component specified design pressure or operating pressure, whichever is higher.

3.06 INSPECTION AND BALANCING

A. Statically and dynamically balance each of the individual rotating parts as required to achieve the required field vibration limits.

B. Statically and dynamically balance the completed equipment rotating assembly and drive shaft components.

C. Furnish copies of material and component inspection reports including balancing reports for equipment system components and for the completed rotating assembly.

D. Critical speed of rotating equipment:
   1. Satisfy the following:
      a. The first lateral and torsional critical speed of all constant, variable, and 2-speed driven equipment that is considered rigid such as horizontal pumps, all non-clog pumps, blowers, air compressors, and engines shall be at least 25 percent above the equipment’s maximum operating speed.
      b. The first lateral and torsional critical speed of all constant, variable, and 2-speed driven equipment that is considered flexible or flexibly mounted such as vertical pumps (vertical in-line and vertical non-clog pumps excluded) and fans shall at least 25 percent below the equipment’s lowest operating speed.
      c. The second lateral and torsional critical speed of all constant, variable, and 2-speed equipment that is considered flexible or flexibly mounted shall be at least 25 percent above the maximum operating speed.
3.07 TESTING LEVELS

A. Level 1 Tests:
   1. Level 1 General Equipment Performance Test:
      a. For equipment, operate, rotate, or otherwise functionally test for
         15 minutes minimum after components reach normal operating
         temperatures.
      b. Operate at rated design load conditions.
      c. Confirm that equipment is properly assembled, equipment moves or
         rotates in the proper direction, shafting, drive elements, and bearings
         are installed and lubricated in accordance with proper tolerances, and
         that no unusual power consumption, lubrication temperatures, bearing
         temperatures, or other conditions are observed.
   2. Level 1 Pump Performance Test:
      a. Measure flow and head while operating at or near the rated condition;
         for factory testing, testing may be at reduced speeds with flow and
         head corresponding to the rated condition when adjusted for speed using
         the appropriate affinity laws.
      b. Use of a test driver is permitted for factory tests when actual driver is
         given a separate test at its point of manufacture as specified in
         Section 16222 - Low Voltage Motors up to 500 Horsepower or the
         applicable equipment section. Use actual driver for field tests.
      c. Record measured flow, suction pressure, discharge pressure, and make
         observations on bearing temperatures and noise levels.
   3. Level 1 Vibration Test:
      a. Test requirement:
         1) Measure filtered vibration spectra versus frequency in
            3 perpendicular planes at each normally accessible bearing housing
            on the driven equipment, any gears and on the driver; 1 plane of
            measurement to be parallel to the axis of rotation of the component.
         2) Vibration spectra versus frequency shall be in accordance with
            Vibration Acceptance Criteria.
      b. Equipment operating condition: Test at specified maximum speed.
   4. Level 1 Noise Test:
      a. Measure unfiltered overall A-weighted sound pressure level in dBA at
         3 feet horizontally from the surface of the equipment and at a mid-point
         of the equipment height.

B. Level 2 Tests:
   1. Level 2 General Performance Test:
      a. For equipment, operate, rotate, or otherwise functionally test for at least
         2 hours after components reach normal operating temperatures.
      b. Operate at rated design load conditions.
      c. Confirm that equipment is properly assembled, equipment moves or
         rotates in the proper direction, shafting, drive elements, and bearings are
installed and lubricated in accordance with proper tolerances, and that no unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.

2. Level 2 Pump Performance Test:
   a. Test 2 hours minimum for flow and head at the rated condition; for factory testing, testing may be at a reduced speeds with flow and head corresponding to the rated condition when adjusted for speed using the appropriate affinity laws.
   b. Use of a test driver is permitted for factory tests when actual driver is given a separate test at its point of manufacture as specified in Section 16222 - Low Voltage Motors up to 500 Horsepower. Use actual driver for field tests.
   c. Test for flow and head at 2 additional conditions; 1 at 25 percent below the rated flow and 1 at 10 percent above the rated flow.
   d. Record measured flow, suction pressure, discharge pressure, and observations on bearing temperatures and noise levels at each condition.

3. Level 2 Vibration Test:
   a. Test requirement:
      1) Measure filtered vibration spectra versus frequency and measure vibration phase in 3 perpendicular planes at each normally accessible bearing housing on the driven equipment, any gears and on the driver; 1 plane of measurement to be parallel to the axis of rotation of the component; measure actual rotational speeds for each vibration spectra measured using photometric or other tachometer input connected directly to the vibration data collector.
      2) Vibration spectra versus frequency shall be in accordance with Vibration Acceptance Criteria.
   b. Equipment operating condition: Repeat test requirements at design specified maximum speed and at minimum speed for variable speed equipment.
   c. Natural frequency test of field installed equipment:
      1) Excite the installed equipment and support system in 3 perpendicular planes, use same planes as operating vibration measurement planes, and determine the as-installed natural resonant frequency of the driven equipment, the driver, gears, and supports.
      2) Perform test at each bearing housing, at each support pedestal, and for pumps on the suction and discharge piping.
      3) Perform with equipment and attached piping full of intended service or process fluid.

4. Level 2 Noise Test:
   a. Measure filtered A-weighted overall sound pressure level in dBA for each of 8 octave band mid-points beginning at 63 hertz measured at 3 feet horizontally from the surface of the equipment at mid-point height of the noise source.
C. Level 3 Tests:

1. Level 3 General Equipment Performance Tests:
   a. For equipment, operate, rotate, or otherwise functionally test for at least 4 hours after components reach normal operating temperatures.
   b. Operate at rated design load conditions for 1/2 the specified time; operate at each of any other specified conditions for a proportionate share of the remaining test time.
   c. Confirm that equipment is properly assembled, equipment rotates in the proper direction, shafting and bearings are installed and lubricated in accordance with proper tolerances, and that no unusual noise, vibration, or temperatures are observed.
   d. Take appropriate capacity, power or fuel consumption, torque, revolutions per minute, pressure, and temperature readings using appropriate test instrumentation to confirm equipment meets specified performance requirements at the design rated condition.
   e. Bearing temperatures: During maximum speed or capacity performance testing, measure and record the exterior surface temperature of each bearing versus time.

2. Level 3 Pump Performance Test:
   a. Test 4 hours minimum for flow and head at or near the rated condition; for factory testing, testing may be at a reduced speeds with flow and head corresponding to the rated condition when adjusted for speed using the appropriate affinity laws.
   b. Use of a test driver is permitted for factory tests when actual driver is given a separate test at its point of manufacture as specified in Section 16222 - Low Voltage Motors up to 500 Horsepower. Use actual driver for field tests.
   c. Test each specified flow and head condition at the rated speed and test at minimum as well as maximum specified speeds; operate at each test condition for a minimum of 15 minutes; for factory testing, test at other speeds may be omitted if test driver at reduced speeds is used for rated condition testing.
   d. Record measured shaft revolutions per minute, flow, suction pressure, discharge pressure; record measured bearing temperatures (bearing housing exterior surface temperatures may be recorded when bearing temperature devices are not required by the equipment section) and record observations on noise levels.

3. Level 3 Vibration Test:
   a. Requirements: Same as Level 2 vibration test except data taken at each operating condition tested and with additional requirements below.
   b. Perform High Frequency Enveloping Analysis for gears and bearings.
      1) Measure bearing element vibration directly on each bearing cap in a location close as possible to the bearing load zone that provides a smooth surface and direct path to the bearing to detect bearing defects.
2) Report results in units of acceleration versus frequency in cycles per minute.

c. Perform Time Wave Form analysis for gears, low speed equipment and reciprocating equipment; plot true peak amplitude velocity and displacement versus time and label the period between peaks with the likely cause of the periodic peaks (relate the period to a cause).

d. Plot vibration spectra on 3 different plots; peak displacement versus frequency, peak acceleration versus frequency and peak velocity versus frequency.

4. Level 3 Noise Test: Measure filtered, un-weighted overall sound pressure level in dB at 3 feet horizontally from the surface of the equipment at mid-point height and at 4 locations approximately 90 degrees apart in plan view; report results for each of 8 octave band mid-points beginning at 63 hertz.

D. Level 4 Tests:

1. Level 4 General Equipment Performance Test:
   a. For equipment, operate, rotate, or otherwise functionally test for at least 8 hours after components reach normal operating temperatures.
   b. Operate at rated design load conditions for 1/2 the specified time; operate at each of any other specified conditions for a proportionate share of the remaining test time.
   c. Confirm that equipment is properly assembled, equipment rotates in the proper direction, shafting and bearings are installed and lubricated in accordance with proper tolerances, and that no unusual noise, vibration, or temperatures are observed.
   d. Take appropriate capacity, power or fuel consumption, torque, revolutions per minute, pressure and temperature readings, using appropriate test instrumentation to confirm equipment meets specified performance requirements at the design rated condition.
   e. Bearing temperatures: During maximum speed or capacity testing, measure and record the exterior surface temperature of each bearing versus time.

2. Level 4 Pump Performance Test:
   a. Test 8 hours minimum for flow and head; begin tests at or near the rated condition; for factory and field-testing, test with furnished motor at full speed.
   b. Test each specified flow and head condition at the rated speed and test at minimum as well as maximum specified speeds; operate at each test condition for a minimum of 20 minutes or longer as necessary to measure required performance, vibration, and noise data at each test condition.
   c. Record measured shaft revolutions per minute, flow, suction pressure, discharge pressure; record measured bearing temperatures (bearing housing exterior surface temperatures may be recorded when bearing temperature devices not required by the equipment section) and record observations on noise levels.
d. Bearing temperatures: During maximum speed or capacity testing, measure and record the exterior surface temperature of each bearing versus time.

e. Perform efficiency and/or Net Positive Suction Head Required (NPSHr) and/or priming time tests when specified in the equipment section in accordance with the appropriate HI standard and as follows:

1) Perform NPSHr testing at maximum rated design speed, head and flow with test fluids at ambient conditions; at maximum rated speed, test at 15 percent above rated design flow, and 25 percent below rated design flow.

2) Perform efficiency testing with test fluids at maximum rated speed.

3) Perform priming time testing with test fluids at maximum rated speed.

3. Level 4 Vibration Test: Same as Level 3 vibration test.

4. Level 4 Noise Test: Same as Level 3 Noise Test except with data taken at each operating condition tested.

END OF SECTION
SECTION 16050

COMMON WORK RESULTS FOR ELECTRICAL

PART 1   GENERAL

1.01  SUMMARY

A. Section includes:
   1. General requirements applicable to all Electrical Work.
   2. General requirements for electrical submittals.

B. Interfaces to equipment, instruments, and other components:
   1. The Drawings, Specifications, and overall design are based on preliminary information furnished by various equipment manufacturers which identify a minimum scope of supply from the manufacturers. This information pertains to, but is not limited to, instruments, control devices, electrical equipment, packaged mechanical systems, and control equipment provided with mechanical systems.
   2. Provide all material and labor needed to install the actual equipment furnished, and include all costs to add any additional conduit, wiring, terminals, or other electrical hardware to the Work, which may be necessary to make a complete, functional installation based on the actual equipment furnished:
      a. Make all changes necessary to meet the manufacturer’s wiring requirements.
   3. Submit all such changes and additions to the Engineer for acceptance as specified in General Conditions.
   4. Review the complete set of Drawings and Specifications in order to ensure that all items related to the electrical power and control systems are completely accounted for. Include any such items that appear on the Drawings or in the Specifications from another discipline in the scope of Work:
      a. If a conflict between Drawings and Specifications is discovered, refer conflict to the Engineer as soon as possible for resolution.

C. All electrical equipment and systems for the entire Project must comply with the requirements of the Electrical Specifications, whether referenced in the individual Equipment Specifications or not:
   1. The requirements of the Electrical Specifications apply to all Electrical Work specified in other sections.
   2. Inform all vendors supplying electrical equipment or systems of the requirements of the Electrical Specifications.
3. District is not responsible for any additional costs due to the failure of Contractor to notify all subcontractors and suppliers of the Electrical Specifications requirements.

D. Contract Documents:
   1. General:
      a. The Drawings and Specifications are complementary and are to be used together in order to fully describe the Work.
   2. Specifications:
      a. The General and Supplementary Conditions of the Contract Documents govern the Work.
      b. These requirements are in addition to all General Requirements.
   3. Contract Drawings:
      a. The Electrical Drawings show desired locations, arrangements, and components of the Electrical Work in a diagrammatic manner.
      b. Locations of equipment, control devices, instruments, boxes, panels, etc. are approximate only; exercise professional judgment in executing the Work to ensure the best possible installation:
         1) The equipment locations and dimensions indicated on the Drawings are approximate. Use the shop drawings to determine the proper layout, foundation, and pad requirements, etc. for final installation. Coordinate with all subcontractors to ensure that all electrical equipment is compatible with other equipment and space requirements. Make changes required to accommodate differences in equipment dimensions.
         2) Contractor has freedom to select any of the named manufacturers identified in individual specification sections; however, Engineer has designed the spatial equipment layout based upon a single manufacturer and has not confirmed every named manufacturer’s equipment fits in the allotted space. It is Contractor’s responsibility to ensure that equipment being furnished fits within the defined space.
      c. Installation details:
         1) Contract Drawings include typical installation details Contractor is to use to complete Electrical Work. For cases where a typical detail does not apply, develop installation details that may be necessary for completing Work, and submit these details for review by Engineer.
         2) Not all typical installation details are referenced within the Drawing set. Apply and use typical details where appropriate.
      d. Schematic diagrams:
         1) All controls are shown de-energized.
         2) Schematic diagrams show control function only. Incorporate other necessary functions for proper operation and protection of system.
         3) Add slave relays, where required, to provide all necessary contacts for the control system or where needed to function as interposing
relays for control voltage coordination, equipment coordination, or control system voltage drop considerations.

4) Mount all devices shown on motor controller schematic diagrams in the controller compartment enclosure, unless otherwise noted or indicated.

5) Schematic diagrams are to be used in conjunction with the descriptive operating sequences in the Contract Documents. Combine all information and furnish a coordinated and fully functional control system.

E. Alternates/Alternatives:
   1. Coordinate with General Conditions for substitute item provisions.

F. Changes and change orders:
   1. As specified in General Conditions.

1.02 REFERENCES

A. Code compliance:
   1. As specified in Section 01410 - Regulatory Requirements.
   2. The publications are referred to in the text by the basic designation only. The latest edition accepted by the Authority Having Jurisdiction of referenced publications in effect at the time of the bid governs.
   3. The standards listed are hereby incorporated into this Section:
      b. American Society of Civil Engineers (ASCE):
      c. ASTM International (ASTM).
      d. Illuminating Engineering Society (IES).
      e. Institute of Electrical and Electronics Engineers (IEEE).
      f. Insulated Cable Engineers Association (ICEA).
      g. International Code Council (ICC):
            a) AC 156 - Acceptance Criteria for Seismic Certification by Shake Table Testing of Non-Structural Components (ICC-ES AC 156).
      h. International Society of Automation (ISA).
      i. National Electrical Manufacturers Association (NEMA):
         1) 250 - Enclosures for Electrical Equipment (1000 V Maximum).
      j. National Fire Protection Association (NFPA):
         1) 70 - National Electrical Code (NEC).
      k. National Institute of Standards and Technology (NIST).
      l. Underwriters' Laboratories, Inc. (UL).

B. Compliance with laws and regulations:
   1. As specified in General Conditions.
1.03 DEFINITIONS

A. Definitions of terms and other electrical and instrumentation considerations as set forth by:
1. IEEE.
2. NETA.
3. IES.
4. ISA.
5. NEC.
6. NEMA.
7. NFPA.
8. NIST.

B. Specific definitions:
1. FAT: Factory acceptance test.
2. ICSC: Instrumentation and controls subcontractor.
3. LCP: Local control panel: Operator interface panel that may contain an HMI, pilot type control devices, operator interface devices, control relays, etc. and does not contain a PLC or RIO.
4. PCM: Process control module: An enclosure containing any of the following devices: PLC, RTU, or RIO.
5. PCIS: Process control and instrumentation system.
6. RTU: Remote telemetry unit: A controller typically consisting of a PLC, and a means for remote communications. The remote communications devices typically are radios, modems, etc.
7. Space: That portion of the switchgear, motor control center, panelboard, switchboard or control panel that does not physically contain a device but is capable of accepting a device with no modifications to the equipment, i.e., provide all standoffs, bus, and hardware, as part of the space.
8. Spare: That portion of the switchgear, motor control center, panelboard, switchboard or control panel that physically contains a device with no load connections to be made.
9. VCP: Vendor control panel: Control panels that are furnished with particular equipment by a vendor other than the ICSC. These panels may contain PLCs, RIO, OIT, HMI, etc.
10. Unequipped space: That portion of the switchgear, motor control center, panelboard, switchboard or control panel that does not physically contain a device, standoff, bus, hardware, or other equipment.
1.04 SYSTEM DESCRIPTION

A. General requirements:
   1. The Work includes everything necessary for and incidental to executing and completing the Electrical Work indicated on the Drawings and specified in the Specifications and reasonably inferable there from:
      a. The Electrical Drawings are schematic in nature; use the Structural, Architectural, Mechanical, and Civil Drawings for all dimensions and scaling purposes.
   2. It is the intent of these Specifications that the entire electrical power, instrumentation, and control system be complete and operable. Provide all necessary material and labor for the complete system from source of power to final utilization equipment, including all connections, testing, calibration of equipment furnished by others as well as equipment furnished by the Contractor, whether or not specifically mentioned but which are necessary for successful operation.
   3. Provide all Electrical Work, including conduit, field wiring, and connections by the electrical subcontractor under the provisions of the Electrical Specifications for all aspects of the Work.
   4. Coordinate all aspects of the Work with the electrical subcontractor and other subcontractors before bidding in order to ensure that all costs associated with a complete installation are included. The District is not responsible for any change orders due to lack of coordination of the Work between the Contractor, the electrical subcontractor, the other subcontractors or suppliers.
   5. Portions of this Project involve installation in existing facilities and interfaces to existing circuits, power systems, controls, and equipment:
      a. Perform and document comprehensive and detailed field investigations of existing conditions (circuits, power systems, controls, equipment, etc.) before starting any Work. Determine all information necessary to document, interface with, modify, upgrade, or replace existing circuits, power systems, controls, and equipment.
      b. Provide and document interface with, modifications to, upgrades, or replacement of existing circuits, power systems, controls, and equipment.
   6. Provide all trenching, forming, rebar, concrete, back filling, hard surface removal and replacement, for all items associated with the Electrical Work and installation:
      a. As specified in the Contract Documents.
   7. Defective work:
      a. As specified in General Conditions.

B. Existing system:
   1. Modification to the existing Motor Control Center SWBD-5C at Secondary Clarifier Electrical Building.
   2. Modification to the existing Motor Control Center MCC-6M at Chemical Building Electrical Room.
C. Operating facility:
   1. As specified in Section 01140 - Work Restrictions.
   2. The MVRWRF is an operating facility. Portions of this facility must remain fully functional throughout the entire construction period. In consideration of this requirement, comply with the following guidelines:
      a. All outages must be of minimal duration and fully coordinated and agreed to by the District. Adjust the construction schedule to meet the requirements of the District. All changes in schedule and any needs to reschedule are included in the Work.
      b. As weather and water demand conditions dictate, re-adjust the construction schedule to meet the demands placed upon District by its users.
      c. Coordinate the construction and power renovation, bear all costs, so that all existing facilities can continue operation throughout construction.
   3. According to individual circumstances and in compliance with the Drawings, extend or replace conduit and cable connections from existing locations.
   4. The standards of documentation, instrument tagging, cable and conductor ferruling, terminal identification and labeling that apply to the new installation apply equally to the existing installation which forms part of the modified system.

1.05 SUBMITTALS

A. Furnish submittals as specified in this Section.

B. General:
   1. Instruct all equipment suppliers of submittals and operation and maintenance manuals of the requirements in this Section.
   2. Furnish the submittals required by each section in the Electrical Specifications.
   3. Adhere to the wiring numbering scheme specified in Section 16075 - Identification for Electrical Systems throughout the Project:
      a. Uniquely number each wire.
      b. Wire numbers must appear on all Equipment Drawings.
   4. Use equipment and instrument tags, as indicated on the Drawings, for all submittals.

C. Seismic requirements:
   1. Provide electrical equipment with construction and anchorage to supporting structures designed to resist site seismic loads based on the seismic design criteria in Section 01612 - Seismic Design Criteria.
   2. For equipment installed in structures designated as seismic design category C, D, E or F, prepare and submit the following:
      a. Statement of seismic qualification, and special seismic certification:
         1) “Statement of seismic qualification.” Provide manufacturer’s statement that the equipment satisfies the seismic design requirements of the building code indicated in
Section 01410 - Regulatory Requirements, including the requirements of ASCE 7, Chapter 13.

2) “Special seismic certification:” Provide manufacturer’s certification that the equipment, when subjected to shake table testing in accordance with ICC-ES AC 156, meets the “Post-Test Functional Compliance Verification” requirements of ICC-ES AC 156 for “Components with Ip = 1.5.” Compliance shall include both operability and containment of hazardous materials as appropriate to the unit being tested.

b. Substantiating test data: With seismic qualification and special seismic certification statements, submit results of testing in accordance with ICC-ES AC 156.

c. Anchoring design calculations and details:
   1) Submit project-specific drawings and supporting calculations, prepared and sealed by a professional engineer licensed in the state where the Project is being constructed, and showing details for anchoring electrical equipment to its supports and for anchoring supports provided with the equipment to the structure. Prepare calculations in accordance with the requirements of Section 01612 - Seismic Design Criteria.

3. Exemptions: A “statement of seismic qualification” and a “special seismic certification” are not required for the following equipment:
   a. Temporary or moveable equipment.
   b. Equipment anchored to the structure and having a total weight of 20 pounds or less.
   c. Distribution equipment anchored to the structure and having a total unit weight of 3 pounds per linear foot, or less.

D. Submittal organization:
   1. First page:
      b. Name and telephone number of individual who reviewed submittal before delivery to Engineer.
      c. Name and telephone number of individual who is primarily responsible for the development of the submittal.
      d. Place for Contractor’s review stamp and comments.
   2. Next pages:
      a. Provide confirmation of specification compliance:
         1) Specification section: Include with each submittal a copy of the relevant specification section:
            a) Indicate in the left margin, next to each pertinent paragraph, either compliance with a check (v) or deviation with a consecutive number (1, 2, 3).
            b) Provide a list of all numbered deviations with a clear explanation and reason for the deviation.
b. Include a response in writing to each of the Engineer’s comments or questions for submittal packages which are re-submitted:
   1) In the order that the comments or questions were presented throughout the submittal.
   2) Referenced by index section and page number on which the comment appeared.
   3) Acceptable responses to Engineer’s comments are either:
      a) Engineer’s comment or change is accepted and appropriate changes are made.
      b) Explain why comment is not accepted or requested change is not made.
      c) Explain how requirement will be satisfied in lieu of comment or change requested by Engineer.
   4) Any re-submittal, which does not contain responses to the Engineer’s previous comments shall be returned for Revision and Re-submittal.
   5) No further review by the Engineer will be performed until a response for previous comments has been received.

3. Remaining pages:
   a. Actual submittal data:
      1) Organize submittals in exactly the same order as the items are referenced, listed, and/or organized in the specification section.
      2) For submittals that cover multiple devices used in different areas under the same specification section, the submittal for the individual devices must list the area where the device is intended to be used.

E. Submittal requirements:
1. Furnish submittals that are fully indexed with a tabbed divider for every component.
2. Sequentially number pages within the tabbed sections. Submittals and operation and maintenance manuals that are not fully indexed and tabbed with sequentially numbered pages, or are otherwise unacceptable, will be returned without review.
3. Edit all submittals and operation and maintenance manuals so that the submittal specifically applies to only the equipment furnished:
   a. Neatly cross out all extraneous text, options, models, etc. that do not apply to the equipment being furnished, so that the information remaining is only applicable to the equipment being furnished.
4. Submit copies of shop drawings, and product data:
   a. Show dimensions, construction details, wiring diagrams, controls, manufacturers, catalog numbers, and all other pertinent details.
5. Where submittals are required, provide a separate submittal for each specification section. In order to expedite construction, the Contractor may make more than 1 submittal per specification section, but a single submittal may not cover more than 1 specification section:
   a. The only exception to this requirement is when one specification section covers the requirements for a component of equipment specified in another section. (For example, circuit breakers are a component of switchgear. The switchgear submittal must also contain data for the associated circuit breakers, even though they are covered in a different specification section.)

6. Exceptions to Specifications and Drawings:
   a. Include a list of proposed exceptions to the Specifications and Drawings along with a detailed explanation of each.
   b. If there is insufficient explanation for the exception or deviation, the submittal will be returned requiring revision and re-submittal.
   c. Acceptance of any exception is at the sole discretion of the Engineer:
      1) Provide all items (materials, features, functions, performance, etc.) required by the Contract Documents that are not accepted as exceptions.
   d. Replace all items that do not meet the requirements of the Contract Documents, which were not previously accepted as exceptions, even if the submittals contained information indicating the failure to meet the requirements.

7. Specific submittal requirements:
   a. Shop drawings:
      1) Required for materials and equipment listed in this and other sections.
      2) Furnish sufficient information to evaluate the suitability of the proposed material or equipment for the intended use, and for compliance with these Specifications.
      3) Shop drawings requirements:
         a) Front, side, and, rear elevations, and top and bottom views, showing all dimensions.
         b) Locations of conduit entrances and access plates.
         c) Component layout and identification.
         d) Schematic and wiring diagrams with wire numbers and terminal identification.
         e) Connection diagrams, terminal diagrams, internal wiring diagrams, conductor size, etc.
         f) Anchoring method and leveling criteria, including manufacturer’s recommendations for the Project site seismic criteria.
         g) Weight.
         h) Finish.
i) Nameplates:
   (1) As specified in Section 16075 - Identification for Electrical Systems.

j) Temperature limitations, as applicable.

b. Product data:
   1) Submitted for non-custom manufactured material listed in this and other sections and shown on shop drawings.
   2) Include:
       a) Catalog cuts.
       b) Bulletins.
       c) Brochures.
       d) Quality photocopies of applicable pages from these documents.
       e) Identify on the data sheets the Project name, applicable specification section, and paragraph.
       f) Identify model number and options for the actual equipment being furnished.
       g) Neatly cross out options that do not apply or equipment not intended to be supplied.

c. Detailed sequence of operation for all equipment or systems.

F. Operation and maintenance manuals:
   1. Furnish the Engineer with a complete set of written operation and maintenance manuals 8 weeks before Functional Acceptance Testing.
   2. Additional operation and maintenance manual requirements:
       a. Completely index manuals with a tab for each section:
          1) Each section containing applicable data for each piece of equipment, system, or topic covered.
          2) Assemble manuals using the approved shop drawings, and include, the following types of data:
             a) Complete set of 11-inch by 17-inch drawings of all equipment.
             b) Complete set of control schematics.
             c) Complete parts list for all equipment being provided.
             d) Catalog data for all products or equipment furnished.

G. Material and equipment schedules:
   1. Furnish a complete schedule and/or matrix of all materials, equipment, apparatus, and luminaries that are proposed for use:
       a. Include sizes, names of manufacturers, catalog numbers, and such other information required to identify the items.

H. Schedule of values:
   1. In addition to completing all items referred to in the schedule of values, Section E01026 - Schedule of Values, submit per unit material and labor costs used in developing the final bid for the electrical system, for the express purpose of pricing and cost justification for any proposed change orders. In addition to the items shown on the schedule of values, provide per unit
material and labor costs for conduit and wire installation for specific types, sizes, and locations as indicated on the Drawings and Conduit Schedule. It is the responsibility of the electrical subcontractor to prove to the Engineer’s satisfaction that said per unit costs were used in the development of the final Bid amount.

I. Roof penetrations:
   1. Submit details of all portions of the electrical installation that penetrate the roof. Include details showing support of the penetrating component, and the sealing means to be utilized.

J. Record Documents:
   1. Furnish as specified in Section 01770 - Closeout Procedures.

K. Test reports:
   1. As specified in Submittal Procedures.
   2. Include the following:
      a. A description of the test.
      b. List of equipment used.
      c. Name of the person conducting the test.
      d. Date and time the test was conducted.
      e. All raw data collected.
      f. Calculated results.
      g. Each report signed by the person responsible for the test.
   3. Additional requirements for field acceptance test reports are specified in Sections 01756 - Commissioning and 16950 - Field Electrical Acceptance Tests.

L. Calculations:
   1. Where required by specific Electrical Specifications:
      a. Because these calculations are being provided by a registered professional engineer, they will be reviewed for form, format, and content but will not be reviewed for accuracy and calculation means.

1.06 QUALITY ASSURANCE

A. Furnish all equipment listed by and bearing the label of UL or of an independent testing laboratory acceptable to the Engineer and the Authority Having Jurisdiction.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 01600 - Product Requirements.

1.08 PROJECT OR SITE CONDITIONS

A. Site conditions:
   1. Provide an electrical, instrumentation and control system, including all equipment, raceways, and any other components required for a complete
installation that meets the environmental conditions for the Site as specified in the General Requirements and below.

2. Seismic load resistance:
   a. Provide electrical equipment with construction and anchorage to supporting structures designed to resist site seismic loads as specified in Section 01612 - Seismic Design Criteria.

3. Altitude, temperature and humidity:
   a. As specified in Section 01610 - Project Design Criteria.
   b. Provide all electrical components and equipment fully rated for continuous operation at this altitude, with no additional derating factors applied.
   c. Provide additional temperature conditioning equipment to maintain all equipment in non-conditioned spaces subject to these ambient temperatures, with a band of 10 degrees Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit below maximum operating temperature, as determined by the equipment manufacturer’s guidelines:
      1) Provide all power conduits wiring for these devices (e.g. heaters, fans, etc.) whether indicated on the Drawings or not.

4. Site security:
   a. Abide by all security and safety rules concerning the Work on the Site, as specified in Sections E01000 - General Safety Requirements and 01500 - Temporary Facilities and Controls.

5. Outdoor installations:
   a. Provide electrical, instrumentation and control equipment suitable for operation in the ambient conditions where the equipment is located.
   b. Provide heating, cooling, and dehumidifying devices incorporated into and included with electrical equipment, instrumentation and control panels to maintain the enclosures within the rated environmental operating ranges as specified in this Section for the equipment:
      1) Provide all wiring necessary to power these devices.

B. Provide enclosures for electrical, instrumentation and control equipment, regardless of supplier or subcontractor furnishing the equipment, that meet the requirements outlined in NEMA Standard 250 for the following types of enclosures:
   1. NEMA Type 1: Intended for indoor use, primarily to provide a degree of protection from accidental contact with energized parts or equipment.
   2. NEMA Type 4: Intended for indoor or outdoor use, primarily to protect equipment from exposure to windblown dust and rain, splashing or hose directed water, ice formation and freezing.
   3. NEMA Type 4X: Made from corrosion resistant materials and are intended for indoor or outdoor use, primarily to protect equipment from exposure to windblown dust and rain, splashing or hose directed water, ice formation and freezing, and corrosion. Provide specific materials as specified or indicated on the Drawings.
4. NEMA Type 12: Intended for indoor use, primarily to provide a degree of protection from dust, falling dirt and dripping non-corrosive liquids.

5. NEMA Type 6: Rated for submersion.

6. NEMA Type 6P: Rated for prolonged submersion.

7. NEMA Type 7: Intended for installation in locations where explosive or combustible gas or vapors may be present (Class I Division 1 or Class I Division 2) meeting the requirements outlined in Section 16052 - Hazardous Classified Area Construction.

C. Plant area Electrical Work requirements:

1. Provide all Electrical Work in accordance with the following table, unless otherwise specifically indicated on the Drawings:

<table>
<thead>
<tr>
<th>Plant Area</th>
<th>NEMA Enclosure Type</th>
<th>Exposed Conduit Type</th>
<th>ENVIRONMENT</th>
<th>Support Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Secondary Clarifier Electrical Building</td>
<td>1</td>
<td>GRC</td>
<td>C: Clean/Dry</td>
<td>GALV STL</td>
</tr>
<tr>
<td>Storm Drain Pump Station</td>
<td>4X SST</td>
<td>PCS</td>
<td>W: Wet</td>
<td>SST</td>
</tr>
<tr>
<td>Storm Drain Pump Station - Wetwell</td>
<td>7</td>
<td>PCS</td>
<td>H: Class I Div 2</td>
<td>SST</td>
</tr>
<tr>
<td>TEEQ Pond</td>
<td>4X SST</td>
<td>PCS</td>
<td>W: Wet</td>
<td>SST</td>
</tr>
<tr>
<td>Chlorine Contact Basin</td>
<td>4X SST</td>
<td>PCS</td>
<td>X: Corrosive</td>
<td>SST</td>
</tr>
<tr>
<td>Chemical Building Electrical Room</td>
<td>1</td>
<td>GRC</td>
<td>C: Clean/Dry</td>
<td>GAVL STL</td>
</tr>
</tbody>
</table>

2. Modify exposed conduit runs as specified in Section 16130 - Conduits.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING

A. General:

1. As specified in Sections 01312 - Project Meetings and 01756 - Commissioning.
2. Testing requirements are specified in Sections 01756 - Commissioning, 16950 - Field Electrical Acceptance Tests and other sections.
3. General scheduling requirements are specified in Section E01310 - Project Control Schedule.
4. Work restrictions and other scheduling requirements are specified in Section 01140 - Work Restrictions.
5. Commissioning requirements as specified in Section 01756 - Commissioning.

B. Pre-submittal conference:

1. Before producing any submittals, schedule a pre-submittal conference for the purposes of reviewing the entire Project, equipment, control philosophy, schedules, and submittal requirements.
2. Contractor, electrical subcontractor, all suppliers, and individual equipment manufacturers furnishing major pieces of equipment must attend.

1.11 WARRANTY

A. Warrant the Electrical Work as specified in General Conditions:
   1. Provide additional warranty as specified in individual Electrical Specifications.

1.12 SYSTEM START-UP

A. Replace or modify equipment, software, and materials that do not achieve design requirements after installation in order to attain compliance with design requirements:
   1. Following replacement or modification, retest the system and perform additional testing to place the complete system in satisfactory operation and obtain compliance acceptance from the Engineer.

1.13 DISTRICT’S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE

A. Before Substantial Completion, perform all maintenance activities required by any sections of the Specifications including any calibrations, final adjustments, component replacements or other routine service required before placing equipment or systems in service.

   B. Furnish all spare parts as required by other sections of the Specifications.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Provide similar items of same manufacturer throughout the electrical and instrumentation portion of the Project.

   B. Allowable manufacturers are specified in individual Electrical Specifications.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

A. Furnish all materials under this Contract that are new, free from defects, and standard products produced by manufacturers regularly engaged in production of these products and that bear all approvals and labels as required by Specifications.

   B. Provide materials complying with the applicable industrial standard as specified in General Conditions.
C. Stainless steel:
   1. Where stainless steel is indicated or used for any portion of Electrical Work, provide a non-magnetic, corrosion-resistant alloy, ANSI Type 316, satin finish.
   2. Provide exposed screws of the same alloys.
   3. Provide finished material free of any burrs or sharp edges.
   4. Use only stainless steel hardware, when chemically compatible, in all areas that are or could be in contact with corrosive chemicals.
   5. Use stainless steel hardware, when chemically compatible, in all chemical areas or areas requiring NEMA Type 4X construction.
   6. Do not use stainless steel in any area containing chlorine, gas or solution, chlorine products or ferric chloride.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. Provide all equipment that is new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these products.

PART 3 EXECUTION

3.01 EXAMINATION

A. It is the electrical subcontractor's responsibility to be fully familiar with the existing conditions and local requirements and regulations.

B. Comply with pre-bid conference requirements as specified in Notice Inviting Bid.

C. Review site conditions and examine all shop drawings for the various items of equipment in order to determine exact routing and final terminations for all wiring and cables.

3.02 PREPARATION (NOT USED)
3.03 INSTALLATION

A. Equipment locations shown on Electrical Drawings may change due to variations in equipment size or minor changes made by others during construction:
   1. Verify all dimensions indicated on the Drawings:
      a. Actual field conditions govern all final installed locations, distances, and levels.
   2. Review all Contract Documents and approved equipment shop drawings and coordinate Work as necessary to adjust to all conditions that arise due to such changes.
   3. Make minor changes in location of equipment before rough in, as directed by the District or Engineer.
   4. Provide a complete electrical system:
      a. Install all extra conduits, cables, and interfaces as may be necessary to provide a complete and operating electrical system.

B. Install equipment in accordance with accepted installation instructions and anchorage details to meet seismic and wind load requirements at the Project site.

C. Cutting and patching:
   1. Perform all cutting, patching, channeling, core drilling, and fitting required for the Electrical Work, except as otherwise directed:
      a. Secure Engineer's permission before performing any operation likely to affect strength of a structural member such as drilling, cutting or piercing:
         1) Before cutting, channeling, or core drilling any surface, ensure that no penetration of any other systems will be made:
            a) Verify that area is clear and free of conduits, cables, piping, ductwork, post-tensioning cables, etc.
            b) Use tone-locate system or X-ray to ensure that area is clear of obstructions.
      b. Review complete Drawing set to ensure that there are no conflicts or coordination problems before cutting, channeling, or core drilling any surface.
   2. Perform all patching to the same quality and appearance as the original work. Employ the proper tradesmen to secure the desired results. Seal around all conduits, wires, and cables penetrating walls, ceilings, and floors in all locations with a fire stop material, typically:
      a. 3M™: CP 25WB+: Caulk.
      b. 3M™: Fire Barrier: Putty.
   3. Use the installation details indicated on the Drawings as a guide for acceptable sealing methods.

D. Install all conduits and equipment in such a manner as to avoid all obstructions and to preserve headroom and keep openings and passageways clear:
1. Install all conduits and equipment in accordance with working space requirements in accordance with the NEC:
   a. This includes any panel, disconnect switch or other equipment that can be energized while open exposing live parts regardless of whether it is likely to require examination or has serviceable parts.

2. Where the Drawings do not show dimensions for locating equipment, install equipment in the approximate locations indicated on the Drawings:
   a. Adjust equipment locations as necessary to avoid any obstruction or interferences.

3. Where an obstruction interferes with equipment operation or safe access, relocate the equipment.

4. Where the Drawings do not indicate the exact mounting and/or supporting method to be used, use materials and methods similar to the mounting details indicated on the Drawings.

E. Earthwork and concrete:
   1. Install all trenching, shoring, concrete, backfilling, grading and resurfacing associated with the Electrical Work:
      a. Requirements as specified in the Contract Documents.

F. Roof penetrations:
   1. Seal conduit penetrations in accordance with roofing manufacturer’s instructions.

G. Terminations:
   1. Provide and terminate all conductors required to interconnect power, controls, instruments, panels, and all other equipment.

H. Miscellaneous installation requirements:
   1. In case of interference between electrical equipment indicated on the Drawings and the other equipment, notify the Engineer as specified in General Conditions.

   2. Location of manholes and pullboxes indicated on the Drawings are approximate. Coordinate exact location of manholes and pullboxes with Mechanical and Civil Work.

   3. Provide additional manholes or pullboxes to those shown where they are required to make a workable installation.

   4. Circuits of different service voltage:
      a. Voltage and service levels:
         1) Low voltage: 120 V to 480 V.
         2) Instrumentation: Less than 50 VDC.
      b. Install different service voltage circuits in separate raceways, and junction boxes.
I. Labeling:
   1. Provide all nameplates and labels as specified in Section 16075 - Identification for Electrical Systems.

J. Equipment tie-downs:
   1. Anchor all instruments, control panels, and equipment by methods that comply with seismic and wind bracing criteria, which apply to the Site.
   2. All control panels, VCPs, LCPs, RTUs, PCMs, etc., must be permanently mounted and tied down to structures in accordance with the Project seismic criteria.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. For District and Engineer witnessed FAT:
   1. Contractor is responsible for the District’s and Engineer’s costs associated with FAT as specified in Section 01756 - Commissioning.

C. District training:
   1. As specified in Section 01756 - Commissioning and in this Section.

3.08 FIELD QUALITY CONTROL

A. Inspection:
   1. Allow for inspection of electrical system installation as specified in Section 01450 - Quality Control.
   2. Provide any assistance necessary to support inspection activities.
   3. Engineer inspections may include, but are not limited to, the following:
      a. Inspect equipment and materials for physical damage.
      b. Inspect installation for compliance with the Drawings and Specifications.
      c. Inspect installation for obstructions and adequate clearances around equipment.
      d. Inspect equipment installation for proper leveling, alignment, anchorage, and assembly.
      e. Inspect equipment nameplate data to verify compliance with design requirements.
      f. Inspect raceway installation for quality workmanship and adequate support.
      g. Inspect cable terminations.
4. Inspection activities conducted during construction do not satisfy inspection or testing requirements specified in Section 16950 - Field Electrical Acceptance Tests.

B. Field acceptance testing (Functional Testing):
   1. Notify the Engineer when the Electrical Work is ready for field acceptance testing.
   2. Perform the field acceptance tests as specified in Section 16950 - Field Electrical Acceptance Tests.
   3. Record results of the required tests along with the date of test:
      a. Use conduit identification numbers to indicate portion of circuit tested.

C. Workmanship:
   1. Leave wiring in panels, manholes, boxes, and other locations neat, clean, and organized:
      a. Neatly coil and label spare wiring lengths.
      b. Shorten, re-terminate, and re-label excessive used as well as spare wire and cable lengths, as determined by the Engineer.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING

A. As specified in Section 01770 - Closeout Procedures.

B. Remove all foreign material and restore all damaged finishes to the satisfaction of the Engineer and District.

C. Clean and vacuum all enclosures to remove all metal filings, surplus insulation and any visible dirt, dust or other matter before energization of the equipment or system start-up:
   1. Use of compressors or air blowers for cleaning is not acceptable.

D. Clean and re-lamp all new and existing luminaries that were used in the areas affected by the construction, and return all used lamps to the District.

E. As specified in other sections of the Contract Documents.

3.11 PROTECTION

A. Protect all Work from damage or degradation until Substantial Completion.

B. Maintain all surfaces to be painted in a clean and smooth condition.

3.12 SCHEDULES (NOT USED)

END OF SECTION
SECTION 16052
HAZARDOUS CLASSIFIED AREA CONSTRUCTION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Executing and completing Work in hazardous and/or classified areas as defined by the NEC Articles 500 through 516, NFPA 820, and specified in the Specifications.

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

1.03 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Specific definitions:
   1. For the purposes of these Specifications, the terms “Hazardous” and “Classified” will be considered synonymous.

1.04 SYSTEM DESCRIPTION (NOT USED)

1.05 SUBMITTALS

A. Furnish submittals as specified in Section 16050 - Common Work Results for Electrical.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Regulatory requirements:
   1. All wiring in hazardous and/or classified locations shall comply with all applicable articles of the NEC, in particular Articles 500 through 516.
   2. Except as modified in Articles 500 through 516, all other applicable rules contained in the NEC shall apply to electric equipment and wiring installed in hazardous and/or classified locations.
   3. All devices used in Class I Division 1 or Division 2 areas must have visible manufacturer installed nameplates specifically stating the Class, Division, and Group for which the device is approved.
1.07 DELIVERY, STORAGE, AND HANDLING
   A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS
   A. A list of hazardous areas is specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING
   A. Conduit seals shall be filled during start-up and commissioning after verification of field wiring. Conduit seals shall be filled prior to the introduction of process or gas to the equipment/area.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY (NOT USED)

1.12 SYSTEM START-UP (NOT USED)

1.13 DISTRICT'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS (NOT USED)

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS
   A. Conduit and sealing fittings:
      1. As specified in Section 16130 - Conduits.

   B. Conduit boxes and bodies:
      1. As specified in Section 16134 - Boxes.

   C. Wiring devices:
      1. As specified in Section 16140 - Wiring Devices.
2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Conduit installation:
   1. As specified in Section 16130 - Conduits.
   2. Wrench tighten all conduit joints to minimize sparking when fault current flows through the conduit system.
   3. Make all conduit connections so that there are a minimum of 5 threads fully engaged in the connection.
   4. Flexible conduit:
      a. Class I Division 1 hazardous areas:
         1) Approved and marked suitable for Class I Division 1.
         2) Listed for compatibility with the group type atmosphere where used.
      b. Class I Division 2 areas:
         1) Liquidtight metal conduit with approved fittings.
      c. Maximum length as specified in Section 16130 - Conduits.

C. Sealing fittings:
   1. Provide an approved seal, no more than 12 inches from the enclosure, for all conduits entering an enclosure containing switches, circuit breakers, fuses, relays, resistors, or any other apparatus which may produce arcs, sparks, or high temperatures:
      a. Only explosion proof unions, couplings, elbows, capped elbows, and conduit bodies similar to “L”, “T”, and “X” may be installed between the sealing fitting and the enclosure.
   2. Provide entire assemblies approved for Class I locations for self-sealing or factory sealed assemblies where the equipment that may produce arcs, sparks, or high temperatures is located in a compartment separate from the
compartment containing splices or taps, and an integral seal is provided where
conductors pass from one compartment to the other:

3. Install a conduit seal within 12 inches of the boundary in each conduit run
entering or leaving a classified location. No union, coupling, box, or fitting is
allowed in the conduit between the sealing fitting and the point at which the
conduit leaves the classified location.

4. For underground conduits entering or leaving a classified location or between
Class I Division 1 and Division 2 locations:

D. Boxes and fittings:

1. Class I Division 1 areas:

E. Outlet boxes and bodies:

1. Provide conduits bodies and boxes suitable for the conduit system as specified
in Section 16130 - Conduits.

2. Class I Division 2 areas:

a. Boxes not containing arcing parts:

b. Provide heavy duty cast construction type conduit fittings and joints:

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pw://Carollo/Documents/Client/CA/EMWD/10546B10/Specifications/16052 (Bid)

a. Seals are required in all conduit connections to the compartment
containing splices and must be within 12 inches of the enclosure.

b. Provide a conduit seal at both points where the conduit emerges from the
ground:

1) Place the conduit seal within 18 inches of finished grade.

2) No union, coupling, box, or fitting is allowed in the conduit system
between seal fitting and the point at which conduit enters the
ground.

5. Separate all conductors within the conduit system and seal using an approved
packing dam installed to both hold the sealing compound and to maintain the
separation between the wires:

6. Install seals with drains in all electrical control stations, low points of conduit
or any place where moisture may condense and accumulate.

7. Install the sealing compound with a minimum thickness of 5/8 inch or the
trade size of the conduit, whichever is greater.
c. Any enclosure containing arcing parts, etc. shall have all construction associated with the enclosure, conduit system, etc. conforming to Class I Division 1 construction.

F. Motor connections:
   1. Conduit installation in Class I Division 1 and Class I Division 2 locations for motors that contain arcing parts, shall proceed as follows:
      a. First - Conduit.
      b. Second - Explosion proof flexible coupling.
      c. Third - Sealing fitting.
      d. Fourth - Explosion proof union.
      e. Fifth - Connection to the motor terminal box.
   2. Wiring connections to motor leads shall be as specified in Section 16150 - Low Voltage Wire Connections.
   3. Bond the non-current-carrying metal parts of equipment, raceways and other enclosures as required by the NEC to ensure electrical continuity.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

   A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

   A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION
SECTION 16060
GROUNDING AND BONDING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Grounding materials and requirements.

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

B. ASTM International (ASTM):

C. Institute of Electrical and Electronics Engineers (IEEE):

D. Underwriters Laboratories, Inc. (UL):
   1. 467 - Ground and Bonding Equipment.

1.03 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

A. Ground equipment and raceway systems so that the completed installation conforms to all applicable code requirements.

B. Provide a complete electrical grounding system as specified including but not limited to:
   1. Grounding electrodes.
   2. Bonding jumpers.

C. Provide bonding jumpers and wire, grounding bushings, clamps and appurtenances required for complete grounding system to bond equipment and raceways to equipment grounding conductors.
D. The ground system resistance (electrode to ground) of the completed installation, as determined by tests specified in Section 16950 - Field Electrical Acceptance Tests, shall be:
   1. 5 ohms or less for industrial systems.

1.05 SUBMITTALS

A. Furnish submittals as specified in General Conditions and Section 16050 - Common Work Results for Electrical.

B. Product data:
   1. Catalog cut sheets.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

B. All grounding components and materials shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT/SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 DISTRICT'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Compression connectors: One of the following or equal:
   1. FCI Burndy.
   2. Thomas & Betts.
B. Ground rods: One of the following or equal:
   1. Erico.
   2. Harger.
   3. Conex.

C. Ground cable: One of the following or equal:
   1. Nehring.
   2. Harger.

D. Precast ground well boxes: One of the following or equal:
   1. Brooks Products, 3-RT Valve Box.
   2. Christy Concrete Products, G12 Valve Box.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

A. Ground rod:
   1. Minimum: 3/4-inch diameter, 10 feet long.
   2. Uniform 10 mil covering of electrolytic copper metallically bonded to a rigid steel core:
      a. The copper-to-steel bond shall be corrosion resistant.
   3. In accordance with UL 467.
   4. Sectional type joined by threaded copper alloycouplings.
   5. Fit the top of the rod with a threaded coupling and steel-driving stud.

B. Ground cable:
   1. Requirements:
      a. Soft drawn (annealed).
      b. Concentric lay, coarse stranded in accordance with ASTM B8.
      c. Bare copper in accordance with ASTM B3.
   2. Size is as indicated on the Drawings, but not less than required by the NEC.

C. Compression connectors:
   1. Manufactured of high copper alloy specifically for the particular grounding application.
   2. Suitable for direct burial in earth and concrete.
   3. Identifying compression die number inscription to be impressed on compression fitting.

D. Equipment grounding conductors:
   1. Conductors shall be the same type and insulation as the load circuit conductors.
   2. Minimum size in accordance with the NEC.
E. Grounding electrode conductors:
   1. Minimum size in accordance with the NEC.

F. Main bonding jumpers and bonding jumpers:
   1. Minimum size in accordance with the NEC.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

A. Precast ground well boxes:
   1. Minimum 10-inch interior diameter.
   2. Traffic-rated cast iron cover.
   3. Permanent “GROUND” marking on cover.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Provide a separate, green insulated, grounding conductor in each raceway independent of raceway material:
   1. Multi-conductor power and control cables shall include an integral green insulated grounding conductor.
   2. Provide a separate grounding conductor in each individual raceway for parallel feeders.

C. Provide a separate grounding conductor for each motor and connect at motor terminal box. Do not use bolts securing motor box to frame or cover for grounding connectors.
D. Provide a grounding type bushing with lug for connection of grounding conductor for conduits that originate from each motor control center section, switchboard, or panelboard:
   1. Individually bond these raceways to the ground bus in the equipment.

E. Provide grounding type bushings with lugs for connection of grounding conductor at both ends of metallic conduit runs. Bond ground bushings to the grounding system.

F. Provide a green insulated wire-grounding jumper from the ground screw to a box grounding screw and, for grounding type devices, to equipment grounding conductor.

G. Interconnect the secondary switchgear, switchboard, or panelboard neutral bus to the ground bus in the secondary switchgear, switchboard, or panelboard compartment, only at service entrance point or after a transformer.

H. Duct bank ground system:
   1. Provide a bare copper grounding conductor the entire length of each duct bank, embedded in the concrete of the duct bank as specified in the Specifications.
   2. Bond duct bank ground conductors together where duct banks join, merge, intersect, or split.

I. Ground connections:
   1. All connections to the ground grid system, the duct bank grounding system, equipment, ground rods, etc., shall be made using compression type grounding connectors as indicated on the Drawings, UL listed, and labeled for the application.
   2. Make ground connections in accordance with the manufacturer's instructions.
   3. Do not conceal or cover any ground connections until the Engineer or authorized representative has established and provided written confirmation that every grounding connection is as indicated on the Drawings and specified in the Specifications.

J. Grounding electrode system:
   1. Ground rods:
      a. Locations as indicated on the Drawings.
      b. Length of rods forming an individual ground array shall be equal in length.
      c. Drive ground rods and install grounding conductors before construction of concrete slabs and duct banks.
      d. Pre-crimp all ground rods, as recommended by the manufacturer, before crimping connector to ground rod.
   2. Metal underground water pipe:
      a. Bond metal underground domestic water pipe to grounding electrode system.
3. Metal frame of building or structure:
   a. Bond metal frame of building or structure to grounding electrode system.

4. Extend grounding conductors through concrete to accessible points for grounding equipment and electrical enclosures.

5. Where grounding conductors are not concrete-encased or direct buried, install in Schedule 40 PVC conduit for protection.

6. Install grounding system at each structure where switchgear, motor control centers, switchboards, panelboards, panels, or other electrical equipment are installed.

K. Shield grounding:
   1. Shielded instrumentation cable shall have its shield grounded at one end only unless shop drawings indicate otherwise:
      a. The grounding point shall be at the control panel or at the power source end of the signal carried by the cable.
   2. Terminate the shield drain wire on a dedicated terminal block.
   3. Use manufacturer’s terminal block jumpers to interconnect ground terminals.
   4. Connection to the panel main ground bus shall be via a green No. 12 conductor to the main ground bus for the panel.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING
   A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL
   A. As specified in Section 16050 - Common Work Results for Electrical.
   B. Measure grounding electrode system resistance to ground in accordance with IEEE 81.

3.09 ADJUSTING
   A. Under the direction of the Engineer, add additional parallel connected ground rods and/or deeper driven rods until the ground resistance measurement meets the specified resistance requirements:
      1. Use of salts, water, or compounds to attain the specified ground resistance is not acceptable.

3.10 CLEANING (NOT USED)
3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION
SECTION 16070
HANGERS AND SUPPORTS

PART 1 GENERAL

1.01 SUMMARY
A. Section includes:
   1. Mounting and supporting electrical equipment and components.

1.02 REFERENCES
A. As specified in Section 16050 - Common Work Results for Electrical.

B. ASTM International (ASTM):

1.03 DEFINITIONS
A. As specified in Section 16050 - Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION
A. Design requirements:
   1. Conform to the requirements of the Building Code as specified in Section 01410 - Regulatory Requirements.
   2. Demonstrate the following using generally accepted engineering methods:
      a. That the anchors to the structure are adequate to resist the loads generated in accordance with the Building Code and equipment requirements.
      b. That the required load capacity of the anchors can be fully developed in the structural materials to which they are attached.
   3. Design loading and anchoring requirements:
      a. As indicated in the Building Code unless otherwise specified.
      b. Seismic loading requirements:
         1) Freestanding, suspended or wall-hung equipment shall be anchored in place by methods that will satisfy requirements for seismic design specified in Section 16050 - Common Work Results for Electrical.
c. Wind loading requirements:
   1) All exterior equipment shall be anchored in place by methods that will satisfy the requirements for wind design specified in Section 16050 - Common Work Results for Electrical.

d. Minimum safety factor against overturning: 1.5.
e. The foundation and structures to which hangers and supports are attached shall be capable of withstanding all anchor loads.

B. Performance requirements:
   1. Hangers and supports individually and as a system shall resist all weights and code-required forces without deflections and deformations that would damage the supporting elements, the equipment supported, or the surrounding construction.

1.05 SUBMITTALS

A. Furnish submittals as specified in General Conditions and Section 16050 - Common Work Results for Electrical.

B. Product data:
   1. Supports:
      b. Geometry.
      c. Manufacturer.
   2. Hardware:
      b. Manufacturer.

C. Shop drawings:
   1. Complete dimensioned and scalable shop drawings of all supporting structures, trapezes, wall supports, etc.
   2. Complete anchoring details for equipment, lighting and raceway, supporting structures, trapezes, wall supports for all equipment in excess of 200 pounds, and all freestanding supports:
      a. Stamped by a professional engineer licensed in the state where the Project is being constructed.
      b. Said submittals, by virtue of the fact that they bear the stamp of a registered engineer, will be reviewed for general consistency with the requirements specified in the Contract Documents, but not for context, accuracy, or method of calculation.
   3. Include data on attachment hardware and construction methods that will satisfy the design loading and anchoring criteria.
D. Installation instructions:
   1. Furnish anchorage instructions and requirements based on the seismic and wind conditions of the Site:
      a. Stamped by a professional engineer licensed in the state where the Project is being constructed.

1.06 QUALITY ASSURANCE
   A. As specified in Section 16050 - Common Work Results for Electrical.

1.07 DELIVERY, STORAGE, AND HANDLING
   A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS
   A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY
   A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM STARTUP
   A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 DISTRICT'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS
   A. One of the following or equal:
      1. Thomas & Betts.
      2. Power-Strut.
      3. Unistrut.
      5. Robroy.
      6. Aickinstrut.

2.02 EXISTING PRODUCTS (NOT USED)
2.03 MATERIALS

A. Use materials appropriate for the area as specified in Section 16050 - Common Work Results for Electrical.

B. Hot dip galvanized steel:
   1. Supports:
      a. In accordance with ASTM A123 or A153.
      b. Minimum zinc coating thickness of 2.5 mils.
   2. Hardware:
      a. Electro-galvanized.
      b. In accordance with ASTM A153.

C. Stainless steel:
   1. Supports:
      a. In accordance with ASTM A240.
      b. ANSI Type 316 material.
   2. Hardware:
      a. ANSI Type 316 material.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

A. Anchor bolts:
   1. As specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES

A. Paint and finish all supporting structures as specified in Section 09960 - High Performance Coating.

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)
3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Mount all raceways, cabinets, boxes, fixtures, instruments, and devices on Contractor-fabricated racks unless otherwise indicated on the Drawings:
   1. Provide the necessary sway bracing to keep trapeze type structures from swaying under seismic events or wind loading.

C. Brace and anchor freestanding equipment supports using methods that provide structural support based on the seismic loads and wind loads:
   1. Lateral deflection at top of supports not to exceed support height divided by 240 unless otherwise approved by the Engineer.

D. Provide fabricated steel support pedestals for wall mounted panels that weigh more than 200 pounds:
   1. Fabricate pedestals out of welded angle, tube sections, or preformed channel.
   2. If the supported equipment is a panel or cabinet, match the supported equipment in physical appearance and dimensions.
   3. Provide auxiliary floor supports for transformers hung from stud walls and weighing more than 200 pounds.

E. Mount all equipment, cabinets, boxes, instruments, and devices in damp or wet locations on minimum of 7/8-inch preformed mounting channel:
   1. Mount channel vertically along the length of the device so that water or moisture may run freely behind the device.

F. Corrosion protection:
   1. Isolate dissimilar metals, except where required for electrical continuity:
      a. Use neoprene washers, 9-mil polyethylene tape, or gaskets for isolation.

G. Raceway:
   1. Furnish all racks and trapeze structures needed to support the raceway from the structure:
      a. Group raceway and position on racks to minimize crossovers.
      b. Provide the necessary bracing to keep trapeze type structures from swaying under loads from cable installation, seismic forces, or wind forces.

H. Anchoring methods:
   1. Solid concrete: Anchor bolts, anchor rods or post-installed anchors as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
   2. Metal surfaces: Machine screws or bolts.
3. Hollow masonry units: Post-installed anchors as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.

I. Recoat or seal all drilled holes, cut or scratched surfaces or with products recommended by the manufacturer.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION
SECTION 16075
IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Identification of electrical equipment, devices and components.

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Occupational Safety and Health Administration (OSHA).

1.03 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

A. Nameplates:
   1. Provide a nameplate for each piece of electrical equipment and devices, control panel and control panel components.
   2. Provide all nameplates of identical style, color, and material throughout the facility.
   3. Device nameplates information:
      a. Designations as indicated on the Drawings and identified on the Process and Instrumentation Drawings.

B. Wire numbers:
   1. Coordinate the wire numbering system with all vendors of equipment so that every field wire has a unique number associated with it for the entire system:
      a. Wire numbers shall correspond to the wire numbers on the control drawings or the panel and circuit numbers for receptacles and lighting.
      b. Wire numbers shall correspond to the terminal block number to which they are attached in the control panel.
      c. Internal panel wires on a common terminal shall have the same wire number.
      d. Multi-conductor cables shall be assigned a cable number that shall be attached to the cable at intermediate pull boxes and stub-up locations.
beneath freestanding equipment. All multi-conductor and instrumentation cables shall be identified at pull points as described above:

2. Provide the following wiring numbering schemes throughout the project for field wires between process control module, (PCM), vendor control panels, (VCP), motor control centers, (MCC), field starters, field instruments, etc.

\[ \text{ORIGIN LOC.} - \text{(ORIGIN TERM.)/} - \text{(DEST. LOC.) - (DEST. TERM.)} \]

Where:

- ORIGIN LOC. = Designation for originating panel or device
- ORIGIN TERM. = Terminal designation at originating panel or device
- DEST. LOC. = Designation for destination panel or device
- DEST. TERM. = Terminal designation at destination panel or device or PLC

I/O address at destination panel:

a. Identify equipment and field instruments as the origin.
b. PCMs are always identified as the destination.
c. Location is the panel designation for VCP, LCP, or PCM. For connections to MCCs, location is the specific starter tag and loop number. Location is the tag and loop number for motor starters, field instruments and equipment. Any hyphen in the panel designation or tag and loop number shall be omitted.
d. Terminal designation is the actual number on the terminal block where the conductor terminates at field devices and vendor control panels. For multi-conductor cables, all terminal numbers shall be shown, separated by commas.
e. Terminal designations at motor leads shall be the motor manufacturer’s standard terminal designation (e.g. T1, T2, T3, etc.).
f. Terminal designations at PCMs where the field conductor connects to field terminal blocks for a PLC input or output shall be the PLC address (Note: the following PLC I/O numbering scheme is typical for Allen-Bradley, the numbering scheme should be modified to match that of the actual PLC manufacturer used for the project):
   1) Discrete Point: W:X:Y/Z.
      Analog Point: W:X:Y.Z.
      Where:
      \[ W = \text{I for input, O for output} \]
X = PLC number (1, 2, 3...)
Y = Slot number (01, 02, 03...)
Z = Terminal number (00, 01, 02...) for a discrete point or a word number for an analog point (1, 2, 3...)
g. Terminal designations at PCMs where the conductor does not connect to a PLC I/O point shall be the terminal number with a “C” prefix (e.g. C0010). For common power after a fuse or neutrals after a switch, the subsequent points shall have and capital letter suffix starting with “A” (e.g. C0010A).

3. Case 1: Vendor control panel (VCP) to process control module (PCM):
Field wire number/label: A-B/C-D
A = Vendor control panel number without hyphen (VCP#)
B = Terminal number within VCP (manufacturer’s or vendor’s standard terminal number)
C = Process control module number without hyphen (PCM#)
D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a “C” prefix if not connected directly to a PLC I/O point (C0010)

Examples: VCP#-10/PCM#-I:1:01/01
VCP#-10/PCM#-O:1:10/07
VCP#-10/PCM#-C0100

4. Case 2: Field instrument to process control module (PCM):
Field wire number/label: E-F/C-D
C = Process control module number without hyphen (PCM#)
D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a “C” prefix if not connected directly to a PLC I/O point (C0010)
E = Field mounted instrument tag and loop numbers without hyphen (EDV#)
F = Manufacturer’s standard terminal number within instrument. Use both terminal numbers for analog points separated by a comma

Examples: TIT#-2,3/PCM#-I:1:01.1
TSH#-1/PCM#-I:2:01/00

5. Case 3: Motor control center (MCC) to vendor control panel (VCP):
Field wire number/label: G-B/A-B
A = Vendor control panel number without hyphen (VCP#)
B = Terminal number within motor control center or vendor control panel (manufacturer’s or vendors standard terminal number)
G = Actual starter designation in the motor control center without hyphen (MMS#)

Example: MMS#-X2/VCP#-10
6. **Case 4**: Motor leads to a motor control center (MCC):
   Field wire number/label: H-I/G-B
   B = Terminal number within motor control center (manufacturer’s standard terminal number)
   G = Actual starter designation in the motor control center without hyphen (MMS#)
   H = Equipment tag and loop number without hyphen (PMP#)
   I = Motor manufacturer’s standard motor lead identification (e.g. T1, T2, T3, etc.)

   Example: PMP-#-T3/MMS#-T3

1.05 **SUBMITTALS**

   A. Furnish submittals as specified in General Conditions and 16050 - Common Work Results for Electrical.

   B. Product data:
      1. Nameplates:
         a. Color.
         b. Size:
            1) Outside dimensions.
            2) Lettering.
         c. Material.
         d. Mounting means.
      2. Nameplate schedule:
         a. Show exact wording for each nameplate.
         b. Include nameplate and letter sizes.
      3. Wire numbers:
         a. Manufacturer’s catalog data for wire labels and label printer.

   C. Record documents:
      1. Update the conduit schedule to reflect the exact quantity of wire numbers including spares and destination points for all wires.

1.06 **QUALITY ASSURANCE (NOT USED)**

1.07 **DELIVERY, STORAGE, AND HANDLING**

   A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 **PROJECT SITE CONDITIONS (NOT USED)**

1.09 **SEQUENCING (NOT USED)**

1.10 **SCHEDULING (NOT USED)**
1.11 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 DISTRICT’S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Nameplates and signs:
   1. One of the following or equal:
      a. Brady.
      b. Seton.

B. Conductor and cable markers:
   1. Heat-shrinkable tubing:
      a. One of the following or equal:
         1) Raychem.
         2) Brady.
         3) Thomas & Betts.
         4) Kroy.

C. Conduit and raceway markers:
   1. Stainless steel, one of the following or equal:
      a. Panduit: Pan Steel.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

A. Nameplates:
   1. Colors:
      a. Warning nameplates: White-center, red face.
      b. Other nameplates: Black-center, white face.
   2. Laminated plastic engraving stock:
      a. 3/32-inch thick material.
      b. 2-ply.
      c. With chamfered edges.
3. Block style engraved characters of adequate size to be read easily from a distance of 6 feet:
   a. No characters smaller than 1/8 inch in height.

B. Signs:
   1. Automatic equipment and high voltage signs:
      a. Suitable for exterior use.
      b. In accordance with OSHA regulations.

C. Conduit and raceway markers:
   1. Stainless steel:
      a. Type 304 or 316.
      b. 3/16" character height.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. Nameplates:
   1. Provide all nameplates for control panel operator devices (e.g. pushbuttons, selector switches, pilot lights, etc.):
      a. Same material and same color and appearance as the device nameplates, in order to achieve an aesthetically consistent and coordinated system.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.
B. Nameplates:
   1. Attach nameplates to equipment with rivets, bolts or sheet metal screws, approved waterproof epoxy-based cement or install in metal holders welded to the equipment.
   2. On NEMA Type 4, NEMA Type 4X, or NEMA Type 7 enclosures, use epoxy-based cement to attach nameplates.
   3. Nameplates shall be aligned and level or plumb to within 1/64 inch over the entire length:
      a. Misaligned or crooked nameplates shall be remounted, or provide new enclosures at the discretion of the Engineer.

C. Conductor and cable markers:
   1. Apply all conductor and cable markers before termination.
   2. Heat-shrinkable tubing:
      a. Tubing shall be shrunk using a heat gun that produces low temperature heated air.
      b. Tubing shall be tight on the wire after it has been heated.
      c. Characters shall face the open panel and shall read from left to right or top to bottom.
      d. Marker shall start within 1/32 inch of the end of the stripped insulation point.

D. Conduit markers:
   1. Furnish and install conduit markers for every conduit in the electrical system that is identified in the conduit schedule or part of the process system:
      a. Conduit markings shall match the conduit schedule.
   2. Mark conduits at the following locations:
      a. Each end of conduits that are greater than 10 feet in length.
      b. The middle of conduits that are 10 feet or less in length.
      c. Where the conduit penetrates a wall or structure.
      d. Where the conduit emerges from the ground, slab, etc.
   3. Mark conduits after the conduits have been fully painted.
   4. Position conduit markers so that they are easily read from the floor.
   5. Attach stainless steel tags with stainless steel cable ties.

E. Signs and labeling:
   1. Furnish and install permanent warning signs at mechanical equipment that may be started automatically or from remote locations:
      a. Fasten warning signs with round head stainless steel screws or bolts.
      b. Locate and mount in a manner to be clearly legible to operations personnel.
   2. Furnish and install permanent and conspicuous warning signs on equipment (front and back), doorways to equipment rooms, pull boxes, manholes, etc. where the voltage exceeds 600 volts.
3. Furnish and install warning signs on equipment that has more than one source of power:
   a. Warning signs to identify every panel and circuit number of the disconnecting means of all external power sources.

4. Place warning signs on equipment that has 120 VAC control voltage source used for interlocking:
   a. Identify panel and circuit number or conductor tag for control voltage source disconnecting means.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING
   A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL
   A. Replace any nameplates, signs, conductor markers, cable markers or raceway labels that in the sole opinion of the Engineer do not meet the Engineer’s aesthetic requirements.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION
SECTION 16123
600-VOLT OR LESS WIRES AND CABLES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. 600-volt class or less wire and cable.

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

B. ASTM International (ASTM):

C. CSA International (CSA).

D. Insulated Cable Engineers Association (ICEA):
   2. NEMA WC 57/ICEA S-73-532 - Standard for Control, Thermocouple Extension, and Instrumentation Cables.

E. National Fire Protection Association (NFPA):
   1. 72 - National Fire Alarm and Signaling Code.

F. Telecommunications Industry Association/Electronics Industry Association (TIA/EIA):
   1. 568-C.2 - Balanced Twisted-Pair Telecommunication Cabling and Components Standard.

G. Underwriter's Laboratories Inc., (UL):
   1. 44 - Thermoset-Insulated Wires and Cables.
   2. 1277 - Standard for Electrical Power and Control Tray Cables with Optional Optical-Fiber Members.
   4. 1569 - Standard for Metal-Clad Cables.
   5. 2196 - Standard for Tests for Fire Resistive Cables.
6. 2225 - Standard for Cables and Cable-Fittings for Use in Hazardous (Classified) Locations.

1.03 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Specific definitions and abbreviations:
   1. AWG: American wire gauge.
   2. BCCS: Bare copper-covered steel.
   3. CPE: Chlorinated polyethylene.
   4. FEP: Fluorinated ethylene propylene.
   5. FHDPE: Foam high-density polyethylene.
   6. FPE: Foam polyethylene.
   7. OD: Outside diameter.
   8. PVC: Polyvinyl chloride.
   9. 9XHHW: Cross-linked high heat water resistant insulated wire.

C. Definitions of terms and other electrical considerations as set forth in the:
   1. ASTM.
   2. ICEA.

1.04 SYSTEM DESCRIPTION

A. Furnish and install the complete wire and cable system.

1.05 SUBMITTALS

A. Furnish submittals as specified in General Conditions and Section 16050 - Common Work Results for Electrical.

B. Product data:
   1. Manufacturer of wire and cable.
   2. Insulation:
      a. Type.
      b. Voltage class.
   3. AWG size.
   4. Conductor material.
   5. Pulling compounds.

C. Shop drawings:
   1. Show splice locations:
      a. For each proposed splice location provide written justification describing why the splice is necessary.

D. Test reports:
   1. Submit test reports for meg-ohm tests.
E. Calculations:
   1. Submit cable pulling calculations to the Engineer for review and comment for all cables that will be installed using mechanical pulling equipment. Show that the maximum cable tension and sidewall pressure will not exceed manufacturer recommended values:
      a. Provide a table showing the manufacturer’s recommended maximum cable tension and sidewall pressure for each cable type and size included in the calculations.
      b. Submit the calculations to the Engineer a minimum of 2 weeks before conduit installation.

1.06 QUALITY ASSURANCE
   A. As specified in Section 16050 - Common Work Results for Electrical.
   B. All wires and cables shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING
   A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY
   A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP
   A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 DISTRICT’S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS
   A. One of the following or equal:
      1. 600-volt class wire and cable:
         a. General Cable.
         b. Okonite Co.
c. Southwire Co.
d. Service Wire.

2. Instrumentation class wire and cable:
   a. Alpha Wire Co.
   b. Belden CDT.
   c. General Cable.
   d. Okonite Co.
   e. Rockbestos Surprenant Cable Corp.

3. Tray cables:
   a. General Cable.
   b. Southwire Co.
   c. Okonite Co.
   d. Service Wire.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

A. Conductors:
   1. Copper in accordance with ASTM B3.

2.04 MANUFACTURED UNITS

A. General:
   1. Provide new wires and cables manufactured within 1 year of the date of
      delivery to the Site.
   2. Permanently mark each wire and cable with the following at 24-inch intervals:
      a. AWG size.
      b. Voltage rating.
      c. Insulation type.
      d. UL symbol.
      e. Month and year of manufacture.
      f. Manufacturer’s name.
   3. Identify and mark wire and cable as specified in Section 16075 - Identification
      for Electrical Systems:
      a. Use integral color insulation for #2 AWG and smaller wire.
      b. Wrap colored tape around cable larger than #2 AWG.

B. 600 volt class wire and cable:
   1. Provide AWG or kcmil sizes as indicated on the Drawings or in the Conduit
      Schedules:
      a. When not indicated on the Drawings, size wire as follows:
         1) In accordance with the NEC:
            a) Use 75 degree Celsius ampacity ratings.
            b) Ampacity rating after all derating factors, equal to or greater
               than rating of the overcurrent device.
2) Provide #12 AWG minimum for power conductors.
3) Provide #14 AWG minimum for control conductors.

2. Provide Class B stranding in accordance with ASTM B8:
   a. Provide Class C stranding where extra flexibility is required.

3. Insulation:
   a. XHHW-2.
   b. 90 degree Celsius rating.

4. Multi-conductor cables:
   a. Number and size of conductors as indicated on the Drawings or in the Conduit Schedules.
   b. Individual conductors with XHHW-2 insulation.
   c. Overall PVC jacket.
   d. Tray cable rated.
   e. Color-coding for control wire in accordance with ICEA Method 1, E-2 in accordance with NEMA WC 57/ICEA S-73-532.
   f. Ground conductor: Insulated, green:
      1) Sized in accordance with NEC.

C. Instrumentation class cable:
1. Type TC.
2. Suitable for use in wet locations.
4. Temperature rating:
   a. 90 degree Celsius rating in dry locations.
   b. 75 degree Celsius rating in wet locations.
5. Conductors:
   a. Insulation:
      1) Flame-retardant PVC, 15 mils nominal thickness, with nylon jacket
         4 mils nominal thickness.
   b. #16 AWG stranded and tinned.
   c. Color code: ICEA Method 1:
      1) Pair: Black and white.
      2) Triad: Black, white and red.
      3) Multiple pairs or triads:
         a) Color-coded and numbered.
6. Drain wire:
   a. #18 AWG.
   b. Stranded, tinned.
7. Jacket:
   a. Flame retardant, moisture and sunlight resistant PVC.
   b. Ripcord laid longitudinally under jacket to facilitate removal.
8. Shielding:
   a. Individual pair/triad:
      1) Minimum 1.35-mil double-faced aluminum foil-polyester tape overlapped to provide 100 percent coverage.
b. Multiple pair or triad shielding:
   1) Group shield: Minimum 1.35-mil double-faced aluminum foil-polyester tape overlapped to provide 100 percent coverage.
   2) Completely isolate group shields from each other.
   3) Cable shield: 2.35 mils double-faced aluminum and synthetic polymer backed tape overlapped to provide 100 percent coverage.

c. All shielding to be in contact with the drain wire.

D. Tray cable:
   1. Provide minimum size #1/0 AWG for single wires, for CT use:
      a. Listed and identified on its surface as suitable for cable tray use.
   2. Provide multi-conductor cable listed and identified on its surface as suitable for cable tray use, Type TC cable in accordance with the NEC:
      a. Provide with an integral white insulated conductor where a neutral is required.
   3. Ambient temperature adjustment in accordance with the NEC.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

A. Wire ties:
   1. One of the following or equal:
      b. Panduit, cable ties.

B. Wire markers:
   1. As specified in Section 16075 - Identification for Electrical Systems.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. Assembly and testing of cable shall comply with the applicable requirements of ICEA S-95-658-1999.

B. Test Type XHHW-2 in accordance with the requirements of UL 44.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)
3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Color-coding:
   1. Color-coding shall be consistent throughout the facility.
   2. The following color code shall be followed for all 240/120 volt and
      208/120 volt systems:
      a. Phase A: Black.
      b. Phase B: Red.
      c. Phase C: Blue.
      d. Single phase system: Black for 1 hot leg, red for the other.
      e. Neutral: White.
      f. High phase or wild leg: Orange.
      g. Equipment ground: Green.
   3. The following color code shall be followed for all 480/277 volt systems:
      b. Phase B: Orange.
      c. Phase C: Yellow.
      d. Neutral: Gray.
      e. Equipment ground: Green.
   4. The following color code shall be followed for all 120 VAC control wiring:
      a. Power: Red.
   5. The following color code shall be followed for all general purpose DC control
      circuits:
      a. Grounded conductors: White with blue stripe.
      b. Ungrounded conductors: Blue.
   6. Switch legs shall be violet. 3-way switch runners shall be pink.
   7. Wires in intrinsically safe circuits shall be light blue.
   8. Wire colors shall be implemented in the following methods:
      a. Wires manufactured of the desired color.
      b. Continuously spiral wrap the first 6 inches of the wire from the
         termination point with colored tape:
         1) Colored tape shall be wrapped to overlap 1/2 of the width of the
            tape.

C. Install conductors only after the conduit installation is complete, and all enclosures
   have been vacuumed clean, and the affected conduits have been swabbed clean and dry:
   1. Install wires only in approved raceways.
   2. Do not install wire:
      a. In incomplete conduit runs.
      b. Until after the concrete work and plastering is completed.
D. Properly coat wires and cables with pulling compound before pulling into conduits:
   1. For all #4 AWG and larger, use an approved wire-pulling lubricant while cable is being installed in conduit:
      a. Ideal Products.
      b. Polywater Products.
      c. 3M Products.
      d. Greenlee Products.
      e. Or equal as recommended by cable manufacturer.
      f. Do not use oil, grease, or similar substances.

E. Cable pulling:
   1. Prevent mechanical damage to conductors during installation.
   2. For cables #1 AWG and smaller, install cables by hand.
   3. For cables larger than #1 AWG, power pulling winches may be used if they have cable tension monitoring equipment.
   4. Provide documentation that maximum cable pulling tension was no more than 75 percent of the maximum recommended level as published by the cable manufacturer. If exceeded, the Engineer may, at his discretion, require replacement of the cable.
   5. Ensure cable pulling crews have all calculations and cable pulling limitations while pulling cable.
   6. Make splices or add a junction box or pullbox where required to prevent cable pulling tension or sidewall pressure from exceeding 75 percent of manufacturer’s recommendation for the specified cable size:
      a. Make splices in manholes or pull boxes only.
      b. Leave sufficient slack to make proper connections.

F. Use smooth-rolling sheaves and rollers when pulling cable into cable tray to keep pulling tension and bending radius within manufacturer’s recommendations.

G. Install and terminate all wire in accordance with manufacturer's recommendations.

H. Neatly arrange and lace conductors in all switchboards, panelboards, pull boxes, and terminal cabinets by means of wire ties:
   1. Do not lace wires in gutter or panel channel.
   2. Install all wire ties with a flush cutting wire tie installation tool:
      a. Use a tool with an adjustable tension setting.
   3. Do not leave sharp edges on wire ties.

I. Terminate stranded conductors on equipment box lugs such that all conductor strands are confined within the lug:
   1. Use ring type lugs if box lugs are not available on the equipment.

J. Lighting circuits:
   1. Each circuit shall have a dedicated neutral.
K. Splices:
   1. Provide continuous circuits from origin to termination whenever possible:
      a. Obtain Engineer’s approval prior to making any splices.
   2. Lighting and receptacle circuit conductors may be spliced without prior
      approval from the Engineer.
   3. Where splices are necessary because of extremely long wire or cable lengths
      that exceed standard manufactured lengths:
      a. Splice box NEMA rating requirements as specified in Section 16050 -
         Common Work Results for Electrical.
      b. Make splices in labeled junction boxes for power conductors.
      c. Make splices for control and instrument conductors in terminal boxes:
         1) Provide terminal boards with setscrew pressure connectors, with
            spade or ring lug connectors.
   4. Power and control conductors routed in common raceways may be spliced in
      common junction boxes.
   5. Clearly label junction and terminal boxes containing splices with the word
      "SPlice LOCATED WITHIN”.
   6. Leave sufficient slack at junction boxes and termination boxes to make proper
      splices and connections. Do not pull splices into conduits.
   7. Install splices with compression type butt splices and insulate using a
      heat-shrink sleeve:
      a. In NEMA Type 4 or NEMA Type 4X areas, provide heat-shrink sleeves that
         are listed for submersible applications.
   8. Splices in below grade pull boxes, in any box subject to flooding, and in wet
      areas shall be made waterproof using:
      a. A heat shrink insulating system listed for submersible applications.
      b. Or an epoxy resin splicing kit.

L. Apply wire markers to all wires at each end after being installed in the conduit and
   before meg-ohm testing and termination.

M. Instrumentation class cable:
   1. Install instrumentation class cables in separate raceway systems from power
      cables:
      a. Install instrument cable in metallic conduit within non-dedicated
         manholes or pull boxes.
      b. Install cable without splices between instruments or between field
         devices and instrument enclosures or panels.
   2. Do not make intermediate terminations, except in designated terminal boxes
      as indicated on the Drawings.
   3. Shield grounding requirements as specified in Section 16060 - Grounding and
      Bonding.

N. Multi-conductor cable:
   1. Where cable is not routed in conduit with a separate ground conductor, use
      1 conductor in the cable as a ground conductor.
O. Use an internal ground conductor, if it is no smaller than as indicated on the Drawings and in accordance with NEC requirements for equipment ground conductor size.

P. Where 2 parallel cables are used, and the internal ground conductor in each cable does not meet NEC requirements for the combined circuit, use 4-conductor cable, with one of the full-sized conductors serving as ground.

Q. Signal cable:
   1. Separate and isolate electrical signal cables from sources of electrical noise and power cables by minimum 12 inches.

R. Submersible cable in wet wells:
   1. Provide Kellem’s grip or stainless steel wire mesh to support cable weight and avoid stress on insulation.

S. Wiring allowances:
   1. Equipment locations may vary slightly from the drawings. Include an allowance for necessary conductors and terminations for motorized equipment, electrical outlets, fixtures, communication outlets, instruments, and devices within 10 linear feet of locations indicated on the Drawings.
   2. Locations for pull boxes, manholes, and duct banks may vary slightly from the drawings. Include an allowance for necessary conductors and related materials to provide conductors to all pull boxes, manholes and duct banks within 20 linear feet of locations indicated on the Drawings.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING
   A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL
   A. As specified in Section 16050 - Common Work Results for Electrical.
   B. Grounding:
      1. As specified in Section 16060 - Grounding and Bonding.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)
3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION
SECTION 16130

CONDUITS

PART 1  GENERAL

1.01  SUMMARY

A. Section includes:
   1. Metallic conduits.
   2. Nonmetallic conduits.
   3. Conduit bodies.
   4. Conduit fittings and accessories.
   5. Conduit installation.

1.02  REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

B. American National Standards Institute (ANSI):
   1. C80.1 - Electrical Rigid Steel Conduit.
   2. C80.3 - Steel Electrical Metallic Tubing.
   3. C80.5 - Electrical Rigid Aluminum Conduit.
   4. C80.6 - Electrical Intermediate Metal Conduit.

C. National Electrical Manufacturer’s Association (NEMA):
   1. RN-1 - Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Steel Conduit.
   2. TC2 - Electrical Polyvinyl Chloride (PVC) Conduit.
   3. TC3 - Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing.
   4. TC7 - Smooth-Wall Coilable Electrical Polyethylene Conduit.
   5. TC13 - Electrical Nonmetallic Tubing.
   6. TC14 - Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.

D. Underwriters Laboratories (UL):
   1. 1 - Standard for Flexible Metal Conduit.
   2. 6 - Standard for Electrical Rigid Metal Conduit - Steel.
   3. 6A - Standard for Electrical Rigid Metal Conduit - Aluminum, Red Brass, and Stainless Steel.
   4. 360 - Standard for Liquidtight Flexible Steel Conduit.
   5. 651 - Standard for Schedule 40 and 80 PVC Conduit and Fittings.
   6. 651B - Standard for Continuous Length HDPE Conduit.
   7. 797 - Standard for Electrical Metallic Tubing - Steel.
   8. 1242 - Standard for Electrical Intermediate Metal Conduit - Steel.
10. 1660 - Standard for Liquidtight Flexible Nonmetallic Conduit.
11. 1684 - Standard for Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.

1.03 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Specific definitions and abbreviations:
   1. Conduit bodies: A separate portion of a conduit system that provides access through a removable cover to the interior of the system at a junction of 2 or more conduit sections. Includes, but not limited to, Shapes C, E, LB, T, X, etc.
   2. Conduit fitting: An accessory that primarily serves a mechanical purpose. Includes, but not limited to, bushings, locknuts, hubs, couplings, reducers, etc.
   3. GRC: Galvanized rigid steel conduit.
   4. PCS: Polyvinyl chloride (PVC) coated rigid steel conduit.
   5. PVC: Polyvinyl chloride rigid nonmetallic conduit.
   6. SLT: Sealtight-liquidtight flexible conduit.
   7. NPT: National pipe thread.

1.04 SYSTEM DESCRIPTION

A. Provide conduits, conduit bodies, fittings, junction boxes, and all necessary components, whether or not indicated on the Drawings, as required, to install a complete electrical raceway system.

1.05 SUBMITTALS

A. Furnish submittals as specified in General Conditions and 16050 - Common Work Results for Electrical.

B. Product data:
   1. Furnish complete manufacturer’s catalog sheets for every type and size of conduit, fitting, conduit body, and accessories to be used on the Project.
   2. Furnish complete manufacturer’s recommended special tools to be used for installation if required.

C. Certifications:
   1. Furnish PVC-coated conduit manufacturer’s certification for each installer.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

B. All conduits, conduit bodies, and fittings shall be UL listed and labeled.
C. Every installer of PVC-coated metallic conduit shall be certified by the manufacturer for installation of the conduit.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Do not expose non-metallic conduit to direct sunlight.

C. Do not store conduit in direct contact with the ground.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING

A. Before installing any conduit or locating any device box:
   1. Examine the complete set of Drawings and Specifications, and all applicable shop drawings.
   2. Verify all dimensions and space requirements and make any minor adjustments to the conduit system as required to avoid conflicts with the building structure, other equipment, or the work of other trades.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 DISTRICT’S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Galvanized rigid steel conduit:
   1. One of the following or equal:
      a. Western Tube and Conduit.
      b. Allied Tube and Conduit.
      c. Wheatland Tube Co.
B. PVC-coated rigid steel conduit:
   1. One of the following or equal:
      a. Robroy Ind.
      b. Ocal, Inc.
      c. Calbond.

C. Sealtight-liquidtight flexible conduit:
   1. One of the following or equal:
      a. Southwire.
      b. AFC Cable Systems.
      c. Electri-Flex Co.
      d. Anaconda.

D. Rigid nonmetallic PVC conduit:
   1. One of the following or equal:
      a. Carlon.
      b. Cantex.
      c. Triangle Conduit and Cable.

E. Conduit bodies:
   1. One of the following or equal:
      a. Crouse-Hinds.
      b. Appleton.
      c. O-Z/Gedney.
      d. Ocal, Inc.
      e. Robroy Ind.
      f. Calbond.
      g. Carlon.

F. Joint compound:
   1. The following or equal:
      a. Thomas and Betts.

G. Conduit sleeve:
   1. One of the following or equal:
      a. Crouse-Hinds.
      b. Appleton.
      c. O-Z/Gedney.

H. Conduit seals:
   1. One of the following or equal:
      a. Appleton.
      b. Crouse-Hinds.
      c. O-Z/Gedney.
I. Conduit hangers and supports:
   1. As specified in Section 16070 - Hangers and Supports.

J. Conduit through wall and floor seals:
   1. The following or equal:
      a. O-Z/Gedney:
         1) Type "WSK."
         2) Type “CSM.”

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS

A. GRC:
   1. All threads: NPT standard conduit threads with a 3/4-inch taper per foot:
      a. Running conduit threads are not acceptable.
   2. Hot-dip galvanized inside and out:
      a. Ensures complete coverage and heats the zinc and steel to a temperature
         that ensures the zinc alloys with the steel over the entire surface.
      b. Electro-galvanizing is not acceptable.
   3. Manufactured in accordance with:
      a. UL-6.
      b. ANSI C80.1.

B. PCS:
   1. The steel conduit, before PVC coating, shall be new, unused, hot-dip
      galvanized material, conforming to the requirements for Type GRC.
   2. Coated conduit NEMA Standard RN-1:
      a. The galvanized coating may not be disturbed or reduced in thickness
         during the cleaning and preparatory process.
   3. Factory-bonded PVC jacket:
      a. The exterior galvanized surfaces shall be coated with primer before PVC
         coating to ensure a bond between the zinc substrate and the PVC coating.
      b. Nominal thickness of the exterior PVC coating shall be 0.040 inch except
         where part configuration or application of the piece dictates otherwise.
      c. PVC coating on conduits and associated fittings shall have no sags,
         blisters, lumps, or other surface defects and shall be free of holes and
         holidays.
d. The PVC adhesive bond on conduits and fittings shall be greater than the tensile strength of the PVC plastic coating:
   1) Confirm bond with certified test results.

4. A urethane coating shall be uniformly and consistently applied to the interior of all conduits and fittings:
   a. Nominal thickness of 0.002 inch.
   b. Conduits having areas with thin or no coating are not acceptable.
   c. All threads shall be coated with urethane.

5. The PVC exterior and urethane interior coatings applied to the conduits shall afford sufficient flexibility to permit field bending without cracking or flaking at temperature above 30 degrees Fahrenheit (-1 degree Celsius).

6. PCS conduit bodies and fittings:
   a. Malleable iron.
   b. The conduit body, before PVC coating, shall be new, unused material and shall conform to appropriate UL standards.
   c. The PVC coating on the outside of conduit bodies shall be 0.040-inch thick and have a series of longitudinal ribs to protect the coating from tool damage during installation.
   d. 0.002-inch interior urethane coating.
   e. Utilize the PVC coating as an integral part of the gasket design.
   f. Stainless steel cover screw heads shall be encapsulated with plastic to ensure corrosion protection.
   g. A PVC sleeve extending 1 conduit diameter or 2 inches, whichever is less, shall be formed at each female conduit opening:
      1) The inside diameter of the sleeve shall be the same as the outside diameter of the conduit to be used.
      2) The sleeve shall provide a vapor- and moisture tight seal at every connection.

C. EFLX:
   1. Suitable for the hazardous Class and Group where installed:
      a. As specified in Section 16050 - Common Work Results for Electrical.
   2. Metallic braid shall provide continuous electrical path.
   4. Provide fittings and unions as required for the installation.

D. PVC:
   1. Extruded from virgin PVC compound:
      a. Schedule 40 unless otherwise specified.
   2. Rated for 90 degrees Celsius conductors or cable.
   3. Rated for use in direct sunlight.

E. Conduit bodies:
   1. Material consistent with conduit type:
      a. Malleable iron bodies and covers when used with Type GRC.
      b. PVC bodies and covers when used with Type PVC.
c. PVC-coated malleable iron bodies and covers when used with Type PCS.

2. Conduit bodies to conform to Form 8, Mark 9, or Mogul design:
   a. Mogul design conforming to NEC requirements for bending space for large conductors for conduit trade sizes of 1 inch and larger with conductors #4 AWG and larger, or where required for wire-bending space.
   b. Use fully insulated bushings on nonmetallic conduit system made of high-impact 150 degrees Celsius rated non-combustible thermosetting phenolic.

3. Gasketed covers attached to bodies with stainless steel screws secured to threaded holes in conduit body.

2.07 ACCESSORIES

A. Connectors and fittings:
   1. Manufactured with compatible materials to the corresponding conduit.

B. Insulated throat metallic bushings:
   1. Construction:
      a. Malleable iron or zinc-plated steel when used with steel conduit.
      b. Positive metallic conduit end stop.
      c. Integrally molded non-combustible phenolic-insulated surfaces rated at 150 degrees Celsius.

C. Insulated grounding bushings:
   1. Construction:
      a. Malleable iron or steel, zinc-plated, with a positive metallic end stop.
      b. Integrally molded non-combustible phenolic-insulated surfaces rated at 150 degrees Celsius.
      c. Tin-plated copper grounding saddle for use with copper or aluminum conductors.

D. Electrical unions (Erickson Couplings):
   1. Construction:
      a. Malleable iron for use with steel conduit.
      b. Concrete tight, 3-piece construction.
      c. Rated for Class I Division 1 Group D in hazardous areas.

E. Hubs for threaded attachment of steel conduit to sheet metal enclosures:
   1. Construction:
      a. Insulated throat.
      b. PVC-coated when used in corrosive areas.
      c. Bonding locknut.
      d. Recessed neoprene o-ring to ensure watertight and dust tight connector.
      e. 1/2-inch through 1-1/4-inch steel zinc electroplated.
      f. 1-1/2-inch through 6-inch malleable iron zinc plated.
2. Usage:
   a. All conduits in damp, wet, outdoor, and corrosive areas shall use threaded hubs for connections to sheet metal enclosures.

F. Sealing fittings:
   1. Construction:
      a. 40-percent wire fill capacity.
      b. PVC-coated when used in corrosive areas.
      c. Malleable ductile iron with steel conduit.
      d. Aluminum with aluminum conduit.
      e. Type EYDX where drains are required.
      f. Type EYSX where drains are not required.
      g. UL listed for use in Class I, Division 1, Groups A, B, C, D; Class I, Division 2, Groups A, B, C, D; and Class II, Divisions 1 and 2, Groups E, F, and G.

2. Sealing compound:
   a. Fiber filler and cement as recommended by the sealing fitting manufacturer.
   b. Approved for the conditions and use:
      1) Not affected by surrounding atmosphere or liquids.
   c. Melting point shall be 200 degrees Fahrenheit minimum.

G. PVC fittings:
   1. Shall include the following:
      a. Couplings.
      b. Terminal adapters.
      c. Female adapters.
      d. Caps.
      e. Reducer bushings.
      f. Duct couplings.
      g. End bells.
      h. Expansion couplings.
      i. Duct couplings: 5 degree.
      j. C-Type pull fittings.
      k. E-Type pull fittings.
      l. LB-Type pull fittings.
      m. LL-Type pull fittings.
      n. LR-Type pull fittings.
      o. T-Type pull fittings.
      p. X-Type pull fittings.
      q. Service entrance caps.

2. Materials:
   a. All devices shall be made of PVC, using the same materials as used for Type PVC conduit.
   b. All metal hardware shall be stainless steel.
H. Through wall and floor seals:
   1. Materials:
      a. Body: Casting of malleable or ductile iron with a hot-dip galvanized finish.
      b. Grommet: Neoprene.
      c. Pressure rings: PVC-coated steel.
      d. Disc material: PVC-coated steel.

I. Expansion/deflection couplings:
   1. Use to compensate for movement in any directions between 2 conduit ends where they connect.
   2. Shall allow movement of 3/4 inch from the normal in all directions.
   3. Shall allow angular movement for a deflection of 30 degrees from normal in any direction.
   4. Constructed to maintain electrical continuity of the conduit system.
   5. Materials:
      a. End couplings: Bronze or galvanized ductile iron.
      b. Sleeve: Neoprene.
      d. Bonding jumper: Tinned copper braid.

J. Expansion couplings:
   1. Shall allow for expansion and contraction of conduit:
      a. Permitting 8-inch movement, 4 inches in either direction.
   2. Constructed to maintain electrical continuity of the conduit system.
   3. Materials:
      a. Head: Malleable or ductile iron.
      b. Sleeve: Steel.
      c. Insulating bushing: Phenolic.
      d. Finish: Hot-dip galvanized.
      e. PVC-coated when used with Type PCS.

K. Conduit markers:
   1. As specified in Section 16075 - Identification for Electrical Systems.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. As specified in Section 16050 - Common Work Results for Electrical.
PART 3  EXECUTION

3.01  EXAMINATION (NOT USED)

3.02  PREPARATION (NOT USED)

3.03  INSTALLATION

A.  As specified in Section 16050 - Common Work Results for Electrical.

B.  General:
   1.  Conduit routing:
      a.  The electrical drawings are diagrammatic in nature:
         1)  Install conduit runs as specified with schematic representation indicated on the Drawings and as specified.
         2)  Modify conduit runs to suit field conditions, as accepted by the Engineer:
            a)  Make changes in conduit locations that are consistent with the design intent but are dimensionally different, or routing to bypass obstructions.
            b)  Make changes in conduit routing due to the relocation of equipment.
         3)  The electrical drawings do not indicate all required junction boxes and pull boxes:
            a)  Provide junction boxes and pull boxes to facilitate wire pulling as required:
               (1)  To meet cable manufacturer’s pulling tension requirements.
               (2)  To limit total conduit bends between pull locations.
            b)  Install junction boxes and pull boxes at locations acceptable to the Engineer.
      b.  The Contractor is responsible for any deviations in general location, conduit size, routing, or changes to the conduit schedule without the express written approval or direction by the Engineer:
         1)  The Engineer is the sole source in determining whether the change is constituted as a deviation.
         2)  Perform any changes resulting in additional conduits, or extra work from such deviations.
         3)  Incorporate any deviations on the Record Documents.
   2.  District Use only tools recommended by the conduit manufacturer for assembling the conduit system.
   3.  Provide adequate clearances from high-temperature surfaces for all conduit runs. Provide minimum clearances as follows:
      a.  Clearance of 6 inches from surfaces 113 degrees Fahrenheit to 149 degrees Fahrenheit.
b. Clearance of 12 inches from surfaces greater than 149 degrees Fahrenheit.

c. Keep conduits at least 6 inches from the coverings on hot water and steam pipes, 18 inches from the coverings on flues and breechings, and 12 inches from fuel lines and gas lines.

d. Where it is necessary to route conduits close to high-temperature surfaces, provide a high-reflectance thermal barrier between the conduit and the surface.

4. Support conduit runs on water-bearing walls a minimum of 7/8-inch away from wall on an accepted preformed channel:
   a. Do not run conduits within water-bearing walls unless otherwise indicated on the Drawings.

5. Do not install 1-inch or larger conduits in or through structural members unless approved by the Engineer.

6. Run conduits exposed to view parallel with or at right angles to structural members, walls, or lines of the building:
   a. Install straight and true conduit runs with uniform and symmetrical elbows, offsets, and bends.
   b. Make changes in direction with long radius bends or with conduit bodies.

7. Install conduits with total conduit bends between pull locations less than or equal to 270 degrees.

8. Route all exposed conduits to preserve headroom, access space and work space, and to prevent tripping hazards and clearance problems:
   a. Install conduit runs so that runs do not interfere with proper and safe operation of equipment and do not block or interfere with ingress or egress, including equipment-removal hatches.
   b. Route conduits to avoid drains or other gravity lines. Where conflicts occur, relocate the conduit as required.

9. When installing conduits through existing slabs or walls, make provisions for locating any possible conflicting items where the conduit is to penetrate. Use tone signal or X-ray methods to make certain that no penetrations will be made into the existing conduits, piping, cables, post-tensioning cables, etc.

10. Plug conduits brought into pull boxes, manholes, handholes, and other openings until used to prevent entrance of moisture.

11. Install conduits through wall and floor seals where indicated on the Drawings.

12. For existing and new 2-inch and larger conduit runs, snake conduits with a conduit cleaner equipped with a cylindrical mandrel of a diameter not less than 85 percent of nominal diameter of the conduit:
   a. Remove and replace conduits through which mandrel will not pass.

13. Provide all sleeves and openings required for the passage of electrical raceways or cables even when these openings or sleeves are not specifically indicated on the Drawings.

14. Install complete conduit systems before conductors are installed.
15. Provide metallic conduits terminating in transformer, switchgear, motor control center, or other equipment conduit windows with grounding bushings and ground with a minimum No. 6 AWG ground wire.

16. Underground conduits:
   a. Install underground conduits, including conduit runs below slabs-on-grade in concrete-reinforced duct bank construction:
      1) As specified in Section 16133 - Duct Banks.
   b. Make underground conduit size transitions at handholes and manholes.
   c. Install spare conduits in underground duct banks towards top center of runs to allow for ease of installation of future cables as conduits enter underground manholes and handholes.
   d. Seal around conduit penetrations of below grade walls with a mechanical seal.

C. Lighting and receptacle conduits:
   1. Provide conduit runs for lighting and receptacle circuits, whether or not indicated on the Drawings.
   2. Install conduits in accordance with the requirements of this Section unless otherwise indicated.
   3. Minimum conduit size:
      a. 3/4-inch for exposed conduits.
      b. 1-inch for underground or in-slab conduits.
   4. Provide conduit materials for the installed location as specified in Section 16050 - Common Work Results for Electrical.

D. Hazardous areas:
   1. As specified in Section 16050 - Common Work Results for Electrical for hazardous areas and specific Class and Division.
   2. As specified in Section 16052 - Hazardous Classified Area Construction for hazardous area conduit installation requirements.

E. Conduit usage:
   1. Exposed conduits:
      a. Rigid conduit:
         1) Install the rigid conduit type for each location as specified in Section 16050 - Common Work Results for Electrical.
         2) Minimum size: 3/4-inch.
      b. Flexible conduit:
         1) Use flexible conduit for final connections between rigid conduit and motors, vibrating equipment, instruments, control equipment, or where required for equipment servicing:
            a) Use Type SLT with rigid metallic conduit.
         2) Minimum size: 3/4-inch:
            a) 1/2 when required for connection to instruments.
3) Maximum length:
   a) Fixed equipment:

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   b) Removable instruments or hinged equipment:
      (1) As required to allow complete removal or full movement without disconnecting or stressing the conduit.

2. Concrete-encased and embedded conduits:
   a. Type PVC Schedule 40 and PVC-coated rigid metallic conduit as specified below:
      1) Use Type PCS in underground and embedded installation as follows:
         a) Stub-up and risers to grade floor or equipment from nonmetallic conduits.
         b) Entering and exiting underground or embedded conduit runs a minimum 12 inches above and below grade of finished floor.
         c) For any and all bends where the total deflection is greater than 45 degrees.
   b. Minimum size:
      1) 2-inch in duct banks unless otherwise indicated on the Drawings.
      2) 1-inch for in-slab conduits unless otherwise indicated on the Drawings.

3. PVC:
   a. Conduit terminations shall be via threaded adapters into threaded hubs on the junction boxes or conduit bodies.
   b. Conduit terminations into boxes without threaded hubs shall utilize a threaded adapter and a flat neoprene washer on the outside of the box:
      1) Use a locknut on the inside of the box to tighten the adapter to the box.
   c. Route conduit to afford it the maximum physical protection:
      1) If necessary, cover conduit to afford additional protection when it cannot be shielded by the structure or machinery frames:
         a) Use Schedule 80 where exposed runs may be subject to physical damage.
F. Conduit joints and bends:

1. General:
   a. Where conduit is underground, under slabs on grade, exposed to the weather, or in NEMA Type 4 or NEMA Type 4X locations, make joints liquidtight.
   b. Keep bends and offsets in conduit runs to an absolute minimum.
   c. All bends shall be symmetrical.
   d. The following conduit systems shall use large-radius sweep elbows:
      1) Underground conduits.
   e. Provide large-radius factory-made bends for 1-1/4-inch trade size or larger.
   f. Make field bends with a radius of not less than the requirements found in the NEC:
      1) The minimum bending radius of the cable must be less than the radius of the conduit bend.
      2) Make all field bends with power bending equipment or manual benders specifically intended for the purpose:
         a) Make bends so that the conduit is not damaged and the internal diameter is not effectively reduced.
         b) For the serving utilities, make bends to meet their requirements.
   g. Replace all deformed, flattened, or kinked conduit.

2. Threaded conduit:
   a. Cut threads on rigid metallic conduit with a standard conduit-cutting die that provides a 3/4-inch per foot taper and to a length such that all bare metal exposed by the threading operation is completely covered by the couplings or fittings used. In addition, cut the lengths of the thread such that all joints become secure and wrench-tight just preceding the point where the conduit ends would butt together in couplings or where conduit ends would butt into the ends or shoulders of other fittings.
   b. Thoroughly ream conduit after threads have been cut to remove burrs.
   c. Use bushings or conduit fittings at conduit terminations.
   d. On exposed conduits, repair scratches and other defects with galvanizing repair stick, Enterprise Galvanizing “Galvabar™,” or CRC “Zinc It.”
   e. Coat conduit threads with an approved electrically conductive sealant and corrosion inhibitor that is not harmful to the conductor insulation:
      1) Apply to the male threads and tighten joints securely.
      2) Clean excess sealant from exposed threads after assembly.
   f. Securely tighten all threaded connections.
   g. Any exposed threaded surfaces must be cleaned and coated with a galvanizing solution so that all exposed surfaces have a galvanized protective coating.

3. PVC:
   a. Use approved solvent-weld cement specifically manufactured for the purpose. Spray-type cement is not allowed.
b. Apply heat for bends so that conduit does not distort or discolor. Use a spring mandrel as required to ensure full inside diameter at all bends:
   1) Utilize a heater specifically for PVC conduit as recommended by the conduit manufacturer.

G. Conduit sealing and drainage:
1. Conduit drainage and sealing other than required for hazardous and classified areas:
   a. Provide sealing and drainage in vertical drops of long (in excess of 20 feet), exterior, above-grade conduit runs at the points at which the conduit enters buildings, switchgear, control panels, lighting panelboards, and other similar enclosures.
   b. Provide seal fittings with drains in vertical drops directly above grade for exterior and above-grade conduit runs that are extended below grade.
   c. Provide conduit seals with drains in areas of high humidity and rapidly changing temperatures:
      1) Where portions of an interior raceway pass through walls, ceilings, or floors that separate adjacent areas having widely different temperatures.
   d. Provide conduit seals similar to O-Z/Gedney (Type CSM) on all conduits between corrosive and non-corrosive areas.
   e. Seal one end only of all underground conduits at highest point with O-Z/Gedney sealing (non-hazardous) filling, or equal.
2. Install seals with drains at any location along conduit runs where moisture may condense or accumulate. This requirement includes, but is not limited to, the following locations: control panels, junction boxes, pullboxes, or low points of the conduit.

H. Conduit supports:
1. General:
   a. Provide appropriate hangers, supports, fasteners, and seismic restraints to suit applications:
      1) As specified in Section 16070 - Hangers and Supports.
      2) Provide support materials consistent with the type of conduit being installed as specified in Section 16050 - Common Work Results for Electrical.
   b. Support conduit at the intervals required by the NEC.
   c. Perforated strap and plumbers tape are not acceptable for conduit supports.
2. Conduit on concrete or masonry:
   a. Use 1-hole malleable iron straps with metallic or plastic expansion anchors and screws or support from preset inserts.
   b. Use preset inserts in concrete when possible.
   c. Use pipe spacers (clamp backs) in wet locations.
3. Suspended conduit:
   a. Use malleable-iron factory-made split-hinged pipe rings with threaded suspension rods sized for the weight to be carried (minimum 3/8-inch diameter), Kindorf, or equal.
   b. For grouped conduits, construct racks with threaded rods and tiered angle iron or preformed channel cross members. Clamp each conduit individually to a cross member. Where rods are more than 2-feet long, provide rigid sway bracing.

4. Supports at structural steel members:
   a. Use beam clamps.
   b. Drilling or welding may be used only as specified or with approval of the Engineer.

5. PVC-coated rigid metal systems:
   a. Provide right-angle beam clamps and “U” bolts specially formed and sized to snugly fit the outside diameter of the coated conduit. Provide "U" bolts with PVC-encapsulated nuts that cover the exposed portions of the threads.
   b. Securely fasten exposed conduits with Type 316 stainless steel clamps or straps.

I. Expansion or expansion/deflection fittings:
   1. General:
      a. Align expansion coupling with the conduit run to prevent binding.
      b. Follow manufacturer’s instructions to set the piston opening.
      c. Install expansion fittings across concrete expansion joints and at other locations where necessary to compensate for thermal or mechanical expansion and contraction.
      d. Furnish fittings of the same material as the conduit system.
   2. For metallic conduit, provide expansion or expansion/deflection couplings, as appropriate, where:
      a. Install expansion fittings a minimum of every 200 feet in straight conduit runs.

J. Empty conduits:
   1. Provide a polyethylene rope rated at 250 pounds tensile strength in each empty conduit more than 10 feet in length.
   2. Seal ends of all conduits with approved, manufactured conduit seals, caps, or plugs immediately after installation:
      a. Keep ends sealed until immediately before pulling conductors.

K. Miscellaneous:
   1. Seal roof penetrations for raceways and other items that penetrate the roof in accordance with roofing manufacturer’s instructions and as indicated on the Drawings.
2. Provide electrical unions at all points of union between ends of rigid conduit systems that cannot otherwise be coupled:
   a. Running threads and threadless couplings are not allowed.
3. Replace any conduits installed that the Engineer determines do not meet the requirements of this Specification.
4. Provide conduit housekeeping curb around all embedded or below-grade conduits exiting or entering the slab, per the Typical Details.

3.04 ERECTION, INSTALLATION, APPLICATIONS, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING
   A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL
   A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION
   A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION
SECTION 16133
DUCT BANKS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Electrical underground duct banks.
   2. Duct bank installation requirements.

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

1.03 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

A. Provide trenching, forming, rebar, spacers, conduit, concrete, backfill, and compaction necessary for the complete installation of the duct banks.

B. Provide reinforced concrete duct banks for all conduits installed below grade, on the site, below structures, or in contact with the earth, unless otherwise indicated on the Drawings.

1.05 SUBMITTALS

A. Furnish submittals as specified in General Conditions and 16050 - Common Work Results for Electrical.

B. Product data:
   1. PVC conduit spacers.
   2. Detectable underground marking tape.
   3. Pull line.

C. Provide applicable submittal documents as specified in:
   1. Section 02318 - Trenching.
   2. Section E03200 - Concrete Reinforcing.
   3. Section E03300 - Cast-In-Place Concrete.
D. Shop drawings:
   1. Submit site plan drawings of duct banks including underground profiles indicating all underground utilities.

1.06 QUALITY ASSURANCE
A. As specified in Section 16050 - Common Work Results for Electrical.

1.07 DELIVERY, STORAGE, AND HANDLING
A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS
A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY
A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP
A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 DISTRICT'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS
A. Conduit spacers:
   1. One of the following or equal:
      b. Cantex.
      c. Osburn Associates, Inc.

B. Detectable underground marking tape:
   1. One of the following or equal:
      a. Blackburn Manufacturing Co.
      b. Pro-Line Safety Products.
      c. Panduit.
C. Pull line:
   1. One of the following or equal:
      a. Arnco.
      b. Greenlee.
      c. Osburn Associates, Inc.

D. Duct seal:
   1. The following or equal:
      a. OZ Gedney type DUX.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

A. Provide conduit as specified in Section 16130 - Conduits:
   1. Use duct suitable for use with 90-degree Celsius rated conductors.

B. Provide reinforcing steel as specified in Section E03200 - Concrete Reinforcing:
   1. Provide minimum Number 4 reinforcing steel.

2.04 MANUFACTURED UNITS

A. Conduit spacers:
   1. Provide conduit spacers recommended by the conduit manufacturer or
      specified above.
   2. Saddle type.
   3. Non-metallic, non-corrosive, non-conductive.
   4. Interlocking type:
      a. Vertical interlocking.
      b. Horizontal interlocking.
   5. Suitable for concrete encasement.
   7. Accommodates 2-inch through 6-inch conduit sizes.
   8. Relieves the conduit from both horizontal and vertical stresses.

B. Pull line:
   1. Minimum 1/4-inch wide, flat design.
   2. Polyester.
   3. Minimum pulling strength 1,200 pounds.

C. Detectable marking tape:
   1. Provide a detectable tape, locatable by a cable or metal detector from above
      the undisturbed grade.
   2. Aluminum core laminated between polyethylene film.
   3. 6-inch wide red tape imprinted with black lettering "CAUTION - BURIED
      ELECTRIC UTILITIES."
D. Duct seal:
   1. Non-hardening sealing compound.
   2. Flexible, can be applied by hand.
   3. UL Listed for use with installed conductors.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES
   A. Concrete mix requirements as specified in Section E03300 - Cast-In-Place Concrete.
   B. Provide a red-oxide conduit encasement coloring agent as specified in Section E03300 - Cast-In-Place Concrete.

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION
   A. As specified in Section 16050 - Common Work Results for Electrical.
   B. Duct banks:
      1. Install duct banks encased in concrete at least 24 inches below finish grade, unless otherwise indicated on the Drawings.
      2. Damage minimization:
         a. Conduit should not be left exposed in an open trench longer than is necessary.
         b. Protect all underground duct banks against damage during pouring of concrete or backfilling.
      3. All plastic conduit fittings to be joined should be exposed to the same temperature conditions for a reasonable length of time before assembly.
      4. Provide No. 4/0 American Wire Gauge bare copper ground wire the entire length of duct bank and bond to the grounding system at each end of the duct bank.
5. Install underground ducts to be self-draining:
   a. Slope duct banks away from buildings to manholes, handholes, or pullboxes.
   b. Slope duct banks uniformly from manholes, handholes, or pullboxes to manholes, handholes, or pullboxes or both ways from high points between manholes, handholes, or pullboxes.
   c. Slope a minimum of 1/4 inch per 10 feet.

6. Where new duct banks join to existing manholes, handholes, or pullboxes, make the proper fittings and fabricate the concrete envelopes to ensure smooth durable transitions, as indicated on the Drawings.

7. Install pull line in spare conduits:
   a. Provide adequate pull line at both ends of conduits to facilitate conductor pulling.
   b. Cap above ground spare conduit risers at each end with screw-on conduit caps.

C. Trenching:
   1. Perform trenching as specified in Section 02318 - Trenching.
   2. Trench must be uniformly graded with the bottom, rock free and covered with select material.
   3. Whenever possible, use the walls of the trench as forms for concrete encasement:
      a. Forms are required where the soil is not self-supporting.
   4. Avoid damaging existing ducts, conduits, cables, and other utilities.

D. Duct spacing:
   1. Separate conduits with manufactured plastic spacers using a minimum space between the outside surfaces of adjacent conduits of 2 inches, unless otherwise indicated on the Drawings.
   2. Install spacers to maintain uniform spacing of duct assembly a minimum of 4 inches above the bottom of the trench during concrete pour. Install spacers on 8-foot maximum intervals:
      a. Due to some distortion of conduit from heat, and other means, it may be necessary to install extra spacers within the duct bank:
         1) Install the intermediate set of spacers within normal required spacing to maintain the proper horizontal clearance:
            a) Clearance is required to allow the proper amount of concrete to infiltrate vertically among the duct to ensure proper protection.
   3. Spacers shall not be located at the center of a bend:
      a. Locate spacer in the tangent, free of the coupling on fabricated bends.
      b. Locate spacers midway between the tangent and the center bend on trench formed sweeps.

E. Terminating:
   1. Use bell ends in duct at entrances into cable vaults.
   2. Make conduit entrances into cable vaults tangential to walls of cable vault.
3. Form trapezoidal transitions between duct bank and cable vaults as needed in order to ensure adequate cable bending radius for the duct bank-to-vault transition.

F. Concrete:
1. Install concrete as specified in Section E03300 - Cast-In-Place Concrete.
2. Provide nonferrous tie wires to prevent displacement of the conduits during pouring of concrete:
   a. Tie wire shall not act as a substitute for spacers.
3. Install minimum 3-inch cover around conduit and rebar.
4. Consolidation of encasement concrete around duct banks shall be by hand puddling, with no mechanical vibration.
5. Conduit is subject to temperature rise. As concrete cures, allow the free end to expand by pouring the concrete from the center of the run or from one tie in point.

G. Marking tape:
1. Install a detectable marking tape 12 inches above the duct bank the entire length of the duct bank.

H. For conduit installations beneath building slabs:
1. Duct banks shall be continued under building slabs to the final destination of the conduits:
   a. Construct separate duct banks as required.
   b. Concrete for encasement under building slabs need not be colored red.
   c. Where duct banks terminate with conduit risers entering building walls, install an expansion/deflection fitting or a flat-wise elbow (elbow parallel to building wall) in order to accommodate differential movement between the conduits and structure.

I. Restore all surfaces to their original condition unless otherwise specified.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING (NOT USED)
3.10 CLEANING
A. Clean conduits of dirt and debris by use of an appropriately sized steel mandrel no less than 1/2 inch smaller than the inside diameter of the conduit.

3.11 PROTECTION
A. As specified in Section 16050 - Common Work Results for Electrical.
B. Provide shoring and pumping to protect the excavation and safety of workers.
C. Protect excavations with barricades as required by applicable safety regulations.

3.12 SCHEDULES (NOT USED)

END OF SECTION
SECTION 16134

BOXES

PART 1  GENERAL

1.01  SUMMARY

A. Section includes:
   1. Device boxes.
   2. Raceway system boxes.

1.02  REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

B. American Association of State Highway and Transportation Officials (AASHTO):

C. ASTM International (ASTM):

D. Joint Industry Conference (JIC).

E. Underwriters Laboratories, Inc. (UL):
   1. 94 - Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.

1.03  DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.
B. Specific definitions:
1. Arcing parts: Circuit breakers, motor controllers, switches, fuses, or any device intended to interrupt current during its operation.
2. Raceway system boxes: Boxes that are used for wire and cable pullboxes, conduit junction boxes, or terminal boxes.

1.04 SYSTEM DESCRIPTION

A. Provide outlet boxes for devices such as switches, receptacles, telephone and computer jacks, security systems, junction, and pullboxes for use in the raceway systems, etc.

B. Provide boxes as indicated on the Drawings or as needed to complete the raceway installation.

1.05 SUBMITTALS

A. Furnish submittals as specified in General Conditions and 16050 - Common Work Results for Electrical.

B. Product data:
   1. Manufacturer.
   3. Dimensions:
      a. Height.
      b. Width.
      c. Depth.
      d. Weight.
      e. NEMA rating.
   4. Conduit entry locations.
   5. Catalog cut sheets.
   6. Installation instructions.

C. Shop drawings:
   1. Include identification and sizes of pullboxes.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Regulatory requirements:
   1. Outlet boxes shall comply with all applicable standards of:
      a. JIC.
      b. NEC.
      c. NEMA.
      d. UL.
1.07  DELIVERY, STORAGE, AND HANDLING
   A.  As specified in Section 16050 - Common Work Results for Electrical.

1.08  PROJECT OR SITE CONDITIONS
   A.  As specified in Section 16050 - Common Work Results for Electrical.

1.09  SEQUENCING
   A.  As specified in Section 16050 - Common Work Results for Electrical.

1.10  SCHEDULING (NOT USED)

1.11  WARRANTY
   A.  As specified in Section 16050 - Common Work Results for Electrical.

1.12  SYSTEM START-UP
   A.  As specified in Section 16050 - Common Work Results for Electrical.

1.13  DISTRICT’S INSTRUCTIONS (NOT USED)

1.14  MAINTENANCE (NOT USED)

PART 2  PRODUCTS

2.01  MANUFACTURERS
   A.  One of the following or equal:
      1.  Cast device boxes:
          a.  Appleton.
          b.  Crouse - Hinds.
          c.  OZ/Gedney.
      2.  Stainless steel enclosures:
          a.  Hoffman.
          b.  Stahlin.
          c.  Rittal.

2.02  EXISTING PRODUCTS (NOT USED)

2.03  MATERIALS (NOT USED)
2.04 MANUFACTURED UNITS

A. Cast device boxes:
   1. Construction:
      a. With internal green ground screw.
      b. Furnished with a suitable gasketed cover.
      c. With integral cast mounting lugs when surface mounted.
      d. Conduit sizes range from 3/4 inch to 1 inch.
      e. Tapered threaded hubs with integral bushing.

2. Aluminum (copper free) boxes:
   a. High strength copper free 4/10 of 1 percent maximum alloy for use with aluminum rigid conduit.

3. Malleable iron boxes:
   a. Conforming to ASTM A47 Grade 32510.

B. Formed steel enclosures:
   1. Stainless steel:
      a. NEMA Type 4X:
         1) Boxes in locations subject to flooding or temporary submersion:
            a) NEMA Type 6.
      b. Fabricated from 14-gauge Type 316 stainless steel.
      c. All seams continuously welded.
      d. Door:
         1) Rolled lip around 3 sides.
         2) Attached to enclosure by means of a continuous stainless steel hinge and pin.
      e. Neoprene door gasket to provide a watertight seal:
         1) Attached with an adhesive.
         2) Retained by a retaining strip.
      f. Fabricate all external removable hardware for clamping the door to the enclosure body from heavy gauge stainless steel:
         1) With a hasp and staple for padlocking.
      g. Provide large enclosures with door and body stiffeners for extra rigidity.
      h. No holes or knockouts.
      i. Finish:
         1) Brushed.
      j. Stainless steel external mounting brackets when surface mounted.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

A. Fasteners:
   1. Electroplated or stainless steel in boxes with wiring devices.
2. Screws, nuts, bolts, and other threaded fasteners:
   a. Stainless steel.

B. Provide breather and drain fittings where appropriate.

C. Internal panels:
   1. Provide internal panels where required for mounting of terminal strips or other equipment.
   2. With plated steel shoulder studs.
   3. Steel with white polyester powder finish.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. General:
   1. Provide materials and construction suitable for environmental conditions at the location of the box as specified in Section 16050 - Common Work Results for Electrical.
   2. Provide outlet box materials to match the conduit system:
      a. PCS - PVC coated cast ferrous boxes.
   3. Solid type gang boxes:
      a. For more than 2 devices.
      b. For barriered outlets.
   4. Support all wall mounted NEMA Type 4 or NEMA Type 4X boxes to maintain a minimum of 7/8-inch free air space between the back of the enclosure and the wall:
      a. Use machined spacers to maintain air space; built-up washers are not acceptable.
      b. Use stainless steel or nylon materials for spacers.
   5. Use cast malleable iron boxes when box must support other devices.
6. Boxes serving luminaires or devices:
   a. Use as pullboxes wherever possible.
7. Fit all cast boxes and pressed steel boxes for flush mounting in concrete with cast, malleable box covers and gaskets.
8. In terminal boxes, furnish terminals as indicated on the Drawings:
   a. Furnish wireways for discrete and analog/DC wiring.
   b. Separate analog wiring from 120 V discrete or power wiring.
9. Size boxes in accordance with NEC requirements and to provide sufficient room for the future components and cables indicated on the Drawings.
10. For fire-rated construction, provide materials and installation for use in accordance with the listing requirements of the classified construction.

C. Outlet boxes:
   1. Locate outlet boxes as indicated on the Drawings:
      a. Adjust locations so as not to conflict with structural requirements or other trades.
   2. Use deep threaded-hub malleable iron or aluminum boxes:
      a. Where exposed to the weather.
      b. In unheated areas.
      c. Where subject to mechanical damage:
         1) Defined as exposed boxes less than 10 feet above the floor.
      d. To act as a pullbox for conductors in a conduit system.
      e. Accommodate wiring devices.
   3. Use deep threaded-hub plastic coated malleable iron boxes in corrosive and NEMA Type 4X area and when the conduit system is PVC coated steel.
   4. Outlet boxes may be used as junction boxes wherever possible.

D. Pullboxes and junction boxes:
   1. Size pullboxes in accordance with NEC requirements and to provide sufficient room for any future conduits and cables as indicated on the Drawings.
   2. Install pullboxes such that access to them is not restricted.

E. For boxes not indicated:
   1. Provide types and mountings as required to suit the equipment and that will be consistent with the conduit system and environmental conditions as indicated in Section 16050 - Common Work Results for Electrical.
   2. Outlet, switch, and junction boxes for flush-mounting in general purpose locations:
      a. One-piece, galvanized, pressed steel.
   3. Ceiling boxes for flush mounting in concrete:
      a. Deep, galvanized, pressed steel.
   4. Outlet, switch, and junction boxes where surface mounted in exposed locations:
      a. Cast ferrous boxes with mounting lugs, zinc or cadmium plating finish.
5. Outlet, control station, and junction boxes for installation in corrosive locations:
   a. Fiberglass reinforced polyester, stainless steel, or plastic coated steel to match the conduit system.
   b. Furnished with mounting lugs.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 REINSTALLATION (NOT USED)

3.07 COMMISSIONING
   A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL
   A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING
   A. As specified in Section 16050 - Common Work Results for Electrical.

3.11 PROTECTION
   A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION
SECTION 16140
WIRING DEVICES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Switches.
   2. Receptacles.
   3. Plates.

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Federal Specifications (FS):
   2. W-S 896/2 - Switches, Toggle (Toggle and Lock), Flush Mounted (General Specification).

C. National Electrical Manufacturers Association (NEMA):
   1. WD1 - General Color Requirements for Wiring Devices.
   2. ICS 5 - Industrial Control and Systems, Control Circuit and Pilot Devices.
   3. OS1 - Sheet-Steel Outlet Boxes, Device Boxes, Covers and Box Supports.
   4. WD6 - Wiring Devices Dimensional Specifications.

D. Underwriters Laboratories, Inc. (UL):
   1. 20 - General Use Snap Switches.
   2. 498 - Standard for Attachment Plugs and Receptacles.
   4. 943 - Ground-Fault Circuit-Interrupters.
   5. 1472 - Solid State Dimming Controls.

1.03 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Specific definitions:
   1. GFCI: Ground fault circuit interrupter.

1.04 SYSTEM DESCRIPTION

A. Switches, receptacles, and plates as indicated on the Drawings wired and operable to form a complete system.
1.05 SUBMITTALS
   A. Furnish submittals as specified in General Conditions and 16050 - Common Work Results for Electrical.
   B. Product data:
      1. Catalog cut sheets.
   C. Shop drawings:
      1. Engraving schedule:
         a. Furnish complete engraving schedule for engraved nameplates.

1.06 QUALITY ASSURANCE
   A. As specified in Section 16050 - Common Work Results for Electrical.
   B. Wiring devices shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING
   A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS
   A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY
   A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP
   A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 DISTRICT'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS
   A. Switches:
      1. One of the following or equal:
         a. Hubbell.
b. Leviton.
c. Cooper Wiring Devices.

B. Receptacles:
   1. General purpose receptacles:
      a. One of the following or equal:
         1) Hubbell.
         2) Leviton.
         3) Cooper Wiring Devices.

C. Plates:
   1. Wet or corrosive areas:
      a. One of the following or equal:
         1) Hubbell.
         2) Cooper Wiring Devices.
         3) Thomas and Betts.
         4) Pass and Seymour.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

A. Switches:
   1. General:
      a. 120-277 VAC.
      b. 20 ampere.
      c. Listed in accordance with UL 20.
      d. Designed and constructed in accordance with FS W-S-896/2.
      e. Back and side wired unless otherwise indicated.
      f. Integral grounding terminal.
      g. Totally enclosed:
         1) Color-coded body with color corresponding to ampere rating.
      h. Provide switches with the operator style and contact arrangement as
         indicated on the Drawings and as required for proper operation.
      i. Color:
         1) Ivory in finished areas.
         2) Brown in all other areas.
   2. General purpose switches:
      a. Toggle type.

B. Receptacles:
   1. Ground fault interrupter receptacles (GFCI):
      a. 125 VAC.
      b. 20 ampere.
c. Trip level 4-6 milliamperes.
d. Individual and feed through protection.
e. UL 943 and UL 498 listed.
f. NEMA Type 5-20R configuration.
g. For damp or wet locations:
   1) Weather resistant, in accordance with UL 498.

C. Plates:
   1. Outdoor and wet areas requiring NEMA Type 4 or NEMA Type 4X enclosures:
      a. General:
         1) UL listed for wet locations.
         2) Gasketed.
         3) Die cast metal:
            a) Match material to box material.
      b. Switches:
         1) Lever operated:
            a) Provide toggle switch.
      c. Receptacles:
         1) Weather proof in-use cover:
            a) Die cast metal construction with electrostatic powder coating
               for corrosion resistance.
            b) Gasketed.
            c) Lockable.
            d) UL listed and in accordance with NEC.
   2. Corrosive areas:
      a. Neoprene.
      b. Gasketed.
      c. Weatherproof.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)
3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Mounting heights:
   1. Process and production areas:
      a. Switches and receptacles 48 inches from finished floor to top of plate.

C. Switches:
   1. Over 300 Volts:
      a. Where switches used in systems of more than 300 volts between conductors, are to be ganged in outlet boxes, provide switches having no exposed live parts or use barriers between the individual switches.

D. Receptacles:
   1. Provide GFCI receptacles as indicated on the Drawings:
      a. Provide weather resistant GFCI receptacles in all wet or damp areas.
      1) As specified in Section 16050 - Common Work Results for Electrical.
   2. Mount non-weatherproof receptacles vertically:
      a. Ground slot down.
   3. Mount weatherproof receptacles horizontally:
      a. Neutral slot up.

E. Ensure all plates make a firm seal with wall for recessed mounted devices:
   1. Outside edges of plates parallel with building lines.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 REINSTALLATION (NOT USED)

3.07 COMMISSIONING

   A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

   A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)
3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION
SECTION 16150
LOW VOLTAGE WIRE CONNECTIONS

PART 1   GENERAL

1.01 SUMMARY

A. Section includes:
   1. Wire connecting devices.
   2. Terminations.

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

B. ASTM International (ASTM):

C. CSA International (CSA):
   1. C22.2 - No. 197-M1983 (R2208) - PVC Insulating Tape.

D. Underwriters Laboratories, Inc. (UL):
   1. 510 - Standard for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape.

1.03 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

A. Provide a complete system of wiring connectors, terminators, fittings, etc. for a complete wiring system suitable for the cables and conductors used.

1.05 SUBMITTALS

A. Furnish submittals as specified in General Conditions and Section 16050 - Common Work Results for Electrical.

B. Product data:
   1. Catalog cut sheets.
   2. Installation instructions.
1.06 QUALITY ASSURANCE
   A. As specified in Section 16050 - Common Work Results for Electrical.
   B. All materials shall be UL listed.

1.07 DELIVERY, STORAGE, AND HANDLING
   A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS
   A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY
   A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP
   A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 DISTRICT’S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS
   A. Manufacturers for each type of technology are specified with the equipment in this Section.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)
2.05 EQUIPMENT

A. Control connections:
   1. Use insulated ring type wire terminators for connections to all screw terminals:
      a. With chamfered/funneled terminal barrel entry.
      b. Deep internal serrations.
      c. Long barrel design to reduce electrical resistance and increased insulator-barrel surface area to ensure that the insulator remains in contact with the barrel.
      d. Electroplated-tin copper conductor.
      e. Manufacturers: The following or equal:
         1) Thomas and Betts, Stakon.
   2. For process equipment connections work from manufacturer's drawings.

B. Joints, splices, taps, and connections:
   1. 600-volt conductors:
      a. Use solderless connectors.
      b. Use only plated copper alloy connectors or lugs:
         1) Aluminum connectors or lugs are not acceptable for copper conductors.
      c. Under those specific conditions where aluminum conductors have been allowed or are specified then the connectors for aluminum conductors shall be specifically designed for that purpose.
      d. For wire Number 10 AWG and smaller use compression splice caps, with insulating caps:
         1) Manufacturers: The following or equal:
            a) Buchanan, 2006S or 2011S, with 2007 or 2014 insulating caps.
      e. For wire Number 8 AWG and larger, use heavy duty copper compression connectors:
         1) Manufacturers: One of the following or equal:
            a) Burndy.
            b) Thomas and Betts.
      f. Heat shrink tubing:
         1) Suitable for indoors, outdoors, overhead, direct burial or submerged applications.
         2) Minimum shrink ratio: 4 to 1.
         3) Continuous operating temperature: -55 degrees Celsius to 110 degrees Celsius.
         4) Internally applied adhesive sealant.
         5) Cross-linked polyolefin:
            a) Manufacturers: One of the following or equal:
               (1) 3M™, ITCSN.
               (2) Thomas & Betts, Shrink-Kon.
C. Insulating tape:
   1. General purpose insulating tape:
      a. Minimum 7 mil vinyl tape.
      b. Suitable for application in an ambient of -18 degrees Celsius
         (0 degrees Fahrenheit).
      c. Operating range up to 105 degrees Celsius (220 degrees Fahrenheit).
      d. Flame retardant, hot- and cold- weather resistant, UV resistant.
      e. For use as a primary insulation for wire cable splices up to 600 VAC.
      f. Meeting and complying with:
         1) ASTM D3005 Type I.
         2) UL 510.
         3) CSA C22.2.
      g. Manufacturers: The following or equal:
         1) 3M™, Scotch Number Super 33+.
   2. General-purpose color-coding tape:
      a. Minimum 7 mil vinyl tape.
      b. Suitable for application on PVC and polyethylene jacketed cables.
      c. For use indoors and outdoors in weather protected enclosures.
      d. Available with the following colors:
         1) Red.
         2) Yellow.
         3) Blue.
         4) Brown.
         5) Gray.
         6) White.
         7) Green.
         8) Orange.
         9) Violet.
      e. For use as phase identification, marking, insulating, and harnessing.
      f. Meeting and complying with:
         1) UL 510.
         2) CSA C22.2.
      g. Manufacturers: The following or equal:
         1) 3M™, Scotch Number 35.

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)
PART 3  EXECUTION

3.01  EXAMINATION (NOT USED)

3.02  PREPARATION (NOT USED)

3.03  INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Load connections:
   1. Connect loads to the circuits as indicated. Color-code all branch circuits as specified in Section 16123 - 600-Volt or Less Wires and Cables.

C. Zero to 600-volt systems:
   1. Make all connections with the proper tool and die as specified by the device manufacturer.
   2. Use only tooling and dies manufactured by the device manufacturer.
   3. Insulate all connections and splices with Scotch 33+ tape and Scotchfill, or premolded plastic covers, or heat shrink tubing and caps.
   4. Number all power and control wires before termination.

D. Motor connections (600 volts and below):
   1. Terminate all leads and wires with compression type ring lugs.
   2. Terminations on all motor leads, including leads that are connected together to accommodate the motor voltage, and the machine wires entering the motor terminal box from the power source, shall have ring type compression lugs.
   3. Cover bolted connectors with a heat shrinkable, cross-linked polyolefin material formed as a single opening boot:
      a. In damp and wet locations, use a complete kit containing mastic that shall seal out moisture and contamination.
      b. Shrink cap with low heat as recommended by manufacturer.
   4. Wire markers shall be readable after boot installation.
   5. Manufacturers: The following or equal:
      a. Raychem, MCK.

3.04  ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05  REPAIR/RESTORATION (NOT USED)

3.06  RE-INSTALLATION (NOT USED)

3.07  COMMISSIONING

A. As specified in Section 01756 - Commissioning.
3.08 FIELD QUALITY CONTROL
   A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION
   A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION
SECTION 16222
LOW VOLTAGE MOTORS UP TO 500 HORSEPOWER

PART 1      GENERAL

1.01 SUMMARY
A. Section includes:
   1. Low voltage motors up to 500 horsepower (hp).

1.02 REFERENCES
A. As specified in Section 16050 - Common Work Results for Electrical.

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

C. American Petroleum Institute (API):

D. ASTM International (ASTM):

E. Institute of Electrical and Electronic Engineers (IEEE):
   1. 43 - IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machinery.
   2. 112 - IEEE Standard Test Procedure for Polyphase Induction Motors and Generators.

F. National Electrical Manufacturers' Association (NEMA):
   1. MG-1 - Motors and Generators.

G. Underwriters Laboratories Inc. (UL):
   1. 674 - Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations.

1.03 DEFINITIONS
A. As specified in Section 16050 - Common Work Results for Electrical.
1.04 SYSTEM DESCRIPTION

A. Furnish and install electric motors and accessories as specified in this Section and the sections specifying driven equipment to provide a complete and operable installation.

1.05 SUBMITTALS

A. Furnish submittals as specified in General Conditions and Section 16050 - Common Work Results for Electrical.

B. Submit completed motor data sheets for each motor supplied:
   1. Conform to data sheet in the appendix of this Section.
   2. Manufacturer’s or other data sheets are not acceptable.

C. Product data:
   1. Descriptive bulletins.
   2. Machine tag and loop number as indicated on the Drawings and in the specification section number of the driven machine.
   3. Complete electrical data.
   4. Torque, current, and power factor versus speed curves:
      a. At 100 percent rated voltage for all full voltage started and VFD-driven motors.
      b. For motors on reduced voltage start at 70, 80, 90, and 100 percent rated voltage.
   5. Accessories data:
      a. Power factor correction capacitors:
         1) Size in KVAR, for all motors not connected to variable frequency drives.
      b. Motor winding heaters:
         1) Voltage.
         2) Watts.
      c. Winding temperature detectors:
         1) Type.
         2) Rating.
      d. Moisture detectors.
   6. Mechanical data:
      a. Bearing design and bearing life calculations.
      b. Resonant frequencies for all VFD-driven motors 50 hp or greater.

D. Shop drawings:
   1. Motor weight.
   2. Frame size.
   3. Conduit box(es), size(s), and location(s).
   4. Outline drawings with dimensions.
   5. Installation details for the project seismic criteria.
E. Test reports:
   1. Factory test reports with test reference standard identified.

F. Certification:
   1. When motors are driven by variable speed drive systems, submit certification that selected motor:
      a. Is capable of satisfactory performance under the intended load.
      b. Meets the requirements of the latest edition of NEMA MG-1 Part 31.

G. Calculations:
   1. Where site conditions specified in Section 16050 - Common Work Results for Electrical exceed manufacturer’s ratings, provide derating calculations for each motor.

1.06 QUALITY ASSURANCE
   A. As specified in Section 16050 - Common Work Results for Electrical.

1.07 DELIVERY, STORAGE, AND HANDLING
   A. As specified in Section 16050 - Common Work Results for Electrical.
   
   B. Motors 200 hp and larger:
      1. Rotate shaft 90 degrees once per month.

1.08 PROJECT OR SITE CONDITIONS
   A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY
   A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP
   A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 DISTRICT’S INSTRUCTION (NOT USED)

1.14 MAINTENANCE (NOT USED)
PART 2  PRODUCTS

2.01  MANUFACTURERS

A. One of the following or equal:
   1. US Motors.
   2. General Electric.
   3. Reliance.
   4. Toshiba.
   5. Baldor.

2.02  EXISTING PRODUCTS (NOT USED)

2.03  MATERIALS (NOT USED)

2.04  MANUFACTURED UNITS (NOT USED)

2.05  EQUIPMENT

A. 3-phase induction motors - general:
   1. Voltage:
      a. All motors 1/2 hp and larger shall be rated 460 V, 3-phase unless otherwise indicated on the Drawings.
      b. Dual voltage motors rated 230/460 V, 3-phase are acceptable provided all leads are brought to the conduit box.
   2. Motors driving identical machines shall be identical.
   3. All motors greater than 1 hp and up to 500 hp shall meet the "NEMA Premium Efficiency" percent listed in NEMA MG-1.
   4. Horsepower as indicated on the Drawings:
      a. Horsepower ratings indicated on the Drawings are based on vendor’s estimates. Provide motors sized for the load of the actual equipment furnished without operating in the service factor.
   5. Service factor:
      a. 1.15 service factor on sine wave power.
      b. 1.0 when driven by VFD.
   6. Torque:
      a. Provide motors that develop sufficient torque for acceleration to full speed at voltage 10 percent less than motor nameplate rating.
      b. When started using reduced voltage starters:
         1) Provide motors that develop sufficient torque for acceleration to full speed.
      c. NEMA Design B except where driven load characteristics require other than normal starting torque:
         1) In no case shall starting torque or breakdown torque be less than the values specified in NEMA MG-1.
7. **Enclosures:**
   a. As specified in the individual equipment Specifications or in this Section.
   b. Totally enclosed fan cooled:
      1) Cast iron conduit box.
      2) Tapped drain holes with Type 316 stainless steel plugs for frames 286 and smaller, and automatic breather and drain devices for frames 324 and larger.
   c. Explosion-proof:
      1) Tapped drain holes with corrosion resistant plugs for frames 286 and smaller and automatic breather and drain devices for frames 324 and larger.
   d. Lifting devices: All motors weighing 265 pounds (120 kilograms) or more shall have suitable lifting devices for installation and removal.

8. Manufactured with cast iron frames in accordance with NEMA MG-1 or manufacturer’s standard material for the specified rating.

9. **Nameplates:**
   a. Provide all motors with a permanent, stainless steel nameplate indelibly stamped or engraved with:
      1) NEMA standard motor data:
         a) Indicate compliance with NEMA MG-1 Part 31 for inverter duty motors.
         2) AFBMA bearing numbers and lubrication instructions.

10. **Hardware:**
    a. Type 316 stainless steel.

11. **Conduit boxes:**
    a. Cast iron or stamped steel.
    b. Split from top to bottom.
    c. Provide gaskets at the following interfaces:
       1) Frames and conduit boxes.
       2) Conduit boxes and box covers.
    d. Rotatable through 360 degrees in 90-degree increments:
       1) Where available based on the size of the conduit box.
    e. Exceeding the dimensions defined in NEMA MG-1.
    f. Provide grounding lugs inside conduit boxes for motor frame grounding.

12. **Motor bearings:**
    a. Antifriction.
    b. Regreaseable and initially filled with grease for horizontal motors and vertical motors per manufacturer’s standard design.
    c. Bearings and lubrication suitable for ambient temperature and temperature rise.
    d. Suitable for intended application and have ABMA L-10 rating life of 60,000 hours or more.
    e. Fit bearings with easily accessible grease supply, flush, drain, and relief fittings using extension tubes where necessary.
f. Where specified in the equipment Specifications, provide split-sleeve type hydrodynamic radial bearings. Provide a bearing isolator to protect bearings from contaminants.

13. Insulation systems:
   a. Motors installed in ambient temperatures 40 degrees Celsius or less:
      1) Provide Class F insulation.
      2) Design temperature rise consistent with Class B insulation.
      3) Rated to operate at an ambient temperature of 40 degrees Celsius at the altitude where the motor will be installed.
   b. Motors installed in ambient temperatures between 40 degrees Celsius and 50 degrees Celsius:
      1) Provide Class F insulation.
      2) Design temperature rise consistent with Class B insulation.
      3) Rated to operate at an ambient temperature of 50 degrees Celsius at the altitude where the motor will be installed.
   c. Motors installed in ambient temperatures between 50 degrees Celsius and 65 degrees Celsius:
      1) Provide Class H insulation.
      2) Design temperature rise consistent with Class F insulation.
      3) Rated to operate at an ambient temperature of 65 degrees Celsius at the altitude where the motors will be installed.

14. Motor leads:
   a. Insulated leads with non-wicking, non-hydroscopic material. Class F insulation.

15. Noise:
   a. Maximum operating noise level in accordance with NEMA MG-1.

B. Submersible motors:
   1. Enclosures:
      a. Totally enclosed non-ventilated (TENV) watertight casing.
      b. Inner and outer shaft seals separated by an oil chamber.
   2. Cooling:
      a. Suitable for continuous operation in totally, partially, or nonsubmerged condition without overheating.
      b. Convection cooling by the surrounding environment or pump cooling by circulating a portion of the pumped media through a cooling water jacket as recommended by the manufacturer based on hp and application.
   3. Electrical cables:
      a. Wire unit without splices. Coordinate with Contractor to ensure cables of adequate length.
      b. Epoxy encapsulated cable entry into terminal box.
   4. Insulation:
      a. Sealed moisture resistant windings.
      b. Class H.
5. Motor protection:
   a. Provide temperature detection in motor windings.
   b. Provide moisture detection in motor housing.
   c. Other detection and protection functions specified in the driven equipment section.

C. Motors installed in hazardous locations:
   1. Class I, Division 1 or Class II, Division 1 areas:
      a. Enclosures:
         1) Explosion proof for 3-phase motors.
         2) UL listed in conformance with UL-674.
         3) UL approval with nameplate and serial number.
   2. Other hazardous areas:
      a. Enclosures:
         1) TEFC for motors in Class I, Division 2 areas.
         2) Vertical motors as specified in this Section.
         3) Hazardous area and temperature code approval stamped on nameplate.

D. Motors installed in corrosive environments:
   1. Nameplate indicating conformance to IEEE 841.
   2. Stator double dipped in varnish and baked.
   3. Stator and rotor coated with corrosion resistant epoxy.
   4. Frame, brackets, fan guard and conduit box coated with minimum of 2 coats of epoxy paint.
   5. Withstand salt spray tests in accordance with ASTM B117.

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)
3.03 INSTALLATION
   A. As specified in Section 16050 - Common Work Results for Electrical.
   B. Install motors in accordance with manufacturer's instructions.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING AND PROCESS START-UP
   A. As specified in Section 01756 - Commissioning.
   B. Factory testing:
      1. Motors less than 250 hp:
         a. Perform manufacturer’s standard production tests including but not limited to:
            1) No load current.
            2) High potential test.
            3) Winding resistance.
         b. Furnish copies of standard test reports on prototype or identical units.

3.08 FIELD QUALITY CONTROL
   A. As specified in Section 16050 - Common Work Results for Electrical.
   B. Before start-up, perform insulation resistance test on each motor furnished or installed on this project:
      1. Windings energized to 1,000 volts DC for 1 minute.
      2. Resistance measured at the end of the test, recorded, and submitted to the Engineer for review.
      3. Inform the Engineer of any unusual or unacceptable test results.
      4. This test is in addition to the acceptance tests in Section 16950 - Field Electrical Acceptance Tests.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION
   A. As specified in Section 16050 - Common Work Results for Electrical.

END OF SECTION
### MOTOR DATA SHEET

**MOTOR/ EQUIPMENT TAG**

**MOTOR NUMBER**

**SPECIFICATION NUMBER OF DRIVEN MACHINE**

---

### MOTOR NAMEPLATE DATA

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<th>MANUFACTURER</th>
<th>MODEL/SERIES</th>
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#### 100% LOAD 75% LOAD 50% LOAD

#### GUARANTEED MINIMUM EFFICIENCIES:

#### GUARANTEED MINIMUM POWER FACTOR:

#### MAXIMUM SIZE OF POWER FACTOR CORRECTION CAPACITOR: _________ KVAR

---

### ACCESSORIES

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<th>WATTS</th>
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WINDING THERMAL PROTECTION

WINDING TEMP SWITCHES (YES/NO)

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RECOMMENDED ALARM DEGREES

RECOMMENDED TRIP DEGREES

---

### SPECIAL APPLICATIONS

INVERTER DUTY* (YES/NO)  PART WINDING (YES/NO)  WYE - DELTA (YES/NO)

2 SPEED, 1 WINDING (YES/NO)  2 SPEED, 2 WINDING (YES/NO)

AREA CLASSIFICATION:

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* Conforms to NEMA MG-1 Part 31.
SECTION 16412

LOW VOLTAGE MOLDED CASE CIRCUIT BREAKERS

PART 1   GENERAL

1.01 SUMMARY

A. Section includes:
   1. Low voltage molded case circuit breakers.

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

B. National Electrical Manufacturers Association (NEMA):
   1. AB 3. - Molded Case Circuit Breakers and Their Application.

C. Underwriter’s Laboratories (UL):
   1. 489 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-
       Breaker Enclosures.
   2. 943 - Ground Fault Circuit Interrupters.

1.03 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

B. In accordance with UL 489.

1.04 SYSTEM DESCRIPTION

A. Molded case thermal magnetic or motor circuit protector type circuit breakers as
   indicated on the Drawings and connected to form a completed system.

1.05 SUBMITTALS

A. Furnish submittals as specified in General Conditions and 16050 - Common Work
   Results for Electrical.

B. Product data:
   1. Catalog cut sheets.
   2. Manufacturer’s time-current curves for all molded case circuit breakers
      furnished.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.
B. Low voltage molded case circuit breakers shall be UL listed and labeled.

1.07 DELIVERY, STORAGE AND HANDLING
A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS
A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY
A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP
A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 DISTRICT’S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS
A. One of the following or equal:
   1. Eaton.
   2. General Electric Co.
   3. Schneider Electric.
   4. ABB.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS
A. General:
   1. Conforming to UL 489.
   2. Operating mechanism:
      a. Quick-make, quick-break, non-welding silver alloy contacts.
      b. Common Trip, Open and Close for multi-pole breakers such that all poles open and close simultaneously.
c. Mechanically trip free from the handle.
d. Trip indicating handle - automatically assumes a position midway between the manual ON and OFF positions to clearly indicate the circuit breaker has tripped.
e. Lockable in the "OFF" position.

3. Arc extinction:
   a. In arc chutes.

4. Voltage and current ratings:
   a. Minimum ratings as indicated on the Drawings.
   b. Minimum frame size 100A.

5. Interrupting ratings:
   a. Minimum ratings as indicated on the Drawings.
   b. Not less than the rating of the assembly (panelboard, switchboard, motor control center, etc.).

B. Motor circuit protectors:
   1. Instantaneous only circuit breaker as part of a listed combination motor controller.
   2. Each pole continuously adjustable in a linear scale with ‘LO’ and ‘HI’ settings factory calibrated.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS

A. Terminals:
   1. Line and load terminals suitable for the conductor type, size, and number of conductors in accordance with UL 489.

B. Case:
   1. Molded polyester glass reinforced.
   2. Ratings clearly marked.

C. Molded case circuit breakers for use in panelboards:
   1. Bolt-on type:
      a. Plug-in type breakers are not acceptable.

2.07 ACCESSORIES

A. Lockable handle:
   1. Provide assembly to lock operating handle in ‘OPEN’ position.
   2. Where a molded case circuit breaker is located in a dedicated enclosure, provide a lockable handle. Reference the Electrical Specifications for additional locking requirements associated with other mounting installations.

2.08 MIXES (NOT USED)
2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. Test breakers in accordance with:
   1. UL 489.
   2. Manufacturer’s standard testing procedures.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Install breakers to correspond to the accepted shop drawings.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING

A. Adjust trip settings in accordance with Protective Device Coordination Study as accepted by the Engineer and in accordance with manufacturer’s recommendations.

B. Adjust motor circuit protectors in accordance with NEC and the manufacturer’s recommendation based on the nameplate values of the installed motor.

3.10 CLEANING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.
3.12 SCHEDULES (NOT USED)

END OF SECTION
SECTION 16422
MOTOR STARTERS

PART 1   GENERAL

1.01 SUMMARY
A. Section includes:
   1. Motor starters and contactors.

1.02 REFERENCES
A. As specified in Section 16050 - Common Work Results for Electrical.
B. International Electrotechnical Commission (IEC):
   1. 60 947-4 - Low-Voltage Switchgear and Control Gear.
C. National Electrical Manufacturer's Association (NEMA):
   1. ICS 2 - Industrial Control and Systems: Controllers, Contactors, and Overload Relays Rated 600 V.
D. Underwriters Laboratories (UL):
   1. 508 - Standard for Industrial Control Equipment.
   2. 508A - Standard for Industrial Control Panels.

1.03 DEFINITIONS
A. As specified in Section 16050 - Common Work Results for Electrical.
B. Specific definitions and abbreviations:
   1. FVNR: Full voltage non-reversing.

1.04 SYSTEM DESCRIPTION
A. General requirements:
   1. Starters for motor control centers, individual enclosed starters, or control panels.

1.05 SUBMITTALS
A. Furnish submittals as specified in General Conditions and 16050 - Common Work Results for Electrical:
   1. Submit motor starter data with equipment submittal.
B. Product data:
   1. Manufacturer.
   2. Catalog cut sheets.
   3. Technical information.
   4. Complete nameplate schedule.
   5. Complete bill of material.
   6. List of recommended spare parts.
   7. Confirmation that the overload relay class for each starter meets the requirements of the equipment and motor supplier.
   8. Electrical ratings:
      a. Phase.
      b. Wire.
      c. Voltage.
      d. Ampacity.
      e. Horsepower.

C. Shop drawings:
   1. Elementary and schematic diagrams:
      a. Provide 1 diagram for every starter and contactor.
      b. Indicate wire numbers for all control wires on the diagrams:
         1) Wire numbering as specified in Section 16075 - Identification for Electrical Systems.
      c. Indicate interfaces with other equipment on the drawings.

D. Operation and maintenance manuals:
   1. Submit complete operating and maintenance instructions presenting full details for care and maintenance of equipment furnished or installed under this Section. Including but not limited to:
      a. Electrical ratings:
         1) Phase.
         2) Wire.
         3) Voltage.
         4) Ampacity.
      b. Complete bill of material.
      c. Manufacturer’s operating and maintenance instructions starter and/or contactor component parts, including:
         1) Protective devices (fuses, breakers, overload relays, heater elements, etc.).
         2) Pilot devices.
      d. Complete renewal parts list.
e. As-built drawings:
   1) Furnish as-built drawings for each starter and contactor indicating final:
      a) Wire numbers.
      b) Interfaces with other equipment.
   2) 11-inch by 17-inch format.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Regulatory requirements:
   1. All starters and components shall be UL listed and labeled:
      a. UL 508 - Industrial Control Equipment.
      b. UL 508A - Industrial Control Panels.
   2. NEMA ICS 2 - Industrial Control and System Controllers; Contactors and Overload Relays Rated: 600 Volts.
   3. Combination starters shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING

1.11 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 DISTRICT’S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE

A. Spare parts:
   1. Provide the following spare parts, suitably packaged and labeled with the corresponding equipment number:
      a. 1 spare fuse of each size and type per starter.
PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. NEMA starters and contactors:
      a. Allen-Bradley.
      b. Schneider Electric.
      c. General Electric.
      d. Eaton.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

A. General:
   1. Provide combination type starters with motor circuit protector or thermal-
      magnetic circuit breaker and control power transformer with ratings.
   2. NEMA size, design, and rated:
      a. NEMA Size 1 minimum.
   3. Coordinate motor circuit protector, thermal magnetic circuit breaker, or
      fusible disconnect, and overload trip ratings with nameplate horsepower and
      current ratings of the installed motor:
      a. If motors provided are different in horsepower rating than those specified
         or indicated on the Drawings, provide starters coordinated to the actual
         motors furnished.
   4. Provide starters NEMA Size 2 and larger with arc quenchers on load breaking
      contacts.
   5. Mount extended overload reset buttons to be accessible for operation
      without opening starter enclosure door.

B. Full voltage starters (FVNR):
   1. Across-the-line full voltage magnetic starters.
   2. Rated for 600 volts.
   3. Provide positive, quick-make, quick-break mechanisms, pad lockable
      enclosure doors.
   4. Furnish starter with solid state electronic overload relays.
   5. Double-break silver alloy contacts.

2.05 EQUIPMENT (NOT USED)
2.06 COMPONENTS

A. Molded case circuit breakers:
   1. Provide as specified in Section 16412 - Low Voltage Molded Case Circuit
      Breakers.

B. Contactors:
   1. NEMA size as specified in equipment specification.
   2. Electrically held:
      a. For lighting loads designed to withstand the initial inrush currents of
         ballast and lamp loads.
   3. Factory adjusted and chatter free.
   4. Auxiliary contacts:
      a. Contact ratings as per NEMA A 600 rating:
         1) Auxiliary contacts rated 10 amps at 600 volts.
      b. Provide at least 1 normally open and 1 normally closed spare auxiliary
         contact.
   5. Constructed in accordance with the following standards:
      a. UL 508.
      b. IEC 947-4:
         1) Type 1 coordination when protected by a circuit breaker.
         2) Type 2 coordination when protected by a suitable UL listed fuse.
      c. IEC 801-1 parts 2 through 6.

C. Overloads:
   1. Solid state electronic:
      a. Selectable Class 10, 20, 30 protection.
      b. Ambient insensitive:
         1) Operating temperature: -20 to 70 degrees Celsius.
      c. Thermal memory.
      d. Protective functions:
         1) Motor overcurrent.
         2) Phase unbalance (adjustable.)
         3) Phase loss.
         4) Ground fault protection.
      e. Self-powered.
      f. Provide current transformers for metering of motor current.
      g. Visible trip indicator.
      h. Push-to-trip test.
      i. Isolated normally open alarm contact.
      j. Normally closed trip contact.
      k. Manual reset.
D. Control power transformer:
   1. Furnish integral control power transformer capacity to power:
      a. All motor controls; Motor and starter accessories indicated on the
         Drawings or specified.
   2. Primary and secondary fusing:
      a. Fusing sized by the manufacturer for the rating of the transformer
         furnished.
   3. Control power transformer secondary voltage:
      a. As required.

2.07 ACCESSORIES

A. Lugs and terminals:
   1. For all external connections of No. 6 AWG and larger.
   2. UL listed for either copper or aluminum conductors.

B. Surge protective devices:
   1. Furnish surge protection devices across the coil of each starter, contactor, and
      relay.

C. Pilot devices:
   1. Provide pilot lights, switches, elapsed time meters, and other devices as
      specified.
   2. As specified in Section 17710 - Control Systems: Panels, Enclosures, and Panel
      Components.

D. Nameplates and wire markers:
   1. As specified in Section 16075 - Identification for Electrical Systems.

E. Conformal coating:
   1. Provide conformal coating material applied to electronic circuitry and printed
      circuit boards to act as protection against moisture, dust, temperature
      extremes, and chemicals such as H₂S and chlorine.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)
3.02 PREPARATION (NOT USED)

3.03 INSTALLATION
   A. As specified in Section 16050 - Common Work Results for Electrical.
   B. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project site.
   C. Starters in control panels:
      1. Install as specified in Section 17710 - Control Systems: Panels, Enclosures, and Panel Components.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING
   A. As specified in Section 01756 - Commissioning.
   B. Factory testing:
      1. District and Engineer will witness the factory acceptance test as specified in Section 16050 - Common Work Results for Electrical.

3.08 FIELD QUALITY CONTROL
   A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING
   A. Make all adjustments as necessary and recommended by the manufacturer, Engineer, or testing firm.
   B. Set all overloads and motor circuit protectors based on the nameplate values of the installed motor.

3.10 CLEANING
   A. As specified in Section 16050 - Common Work Results for Electrical.

3.11 PROTECTION
   A. As specified in Section 16050 - Common Work Results for Electrical.
3.12  SCHEDULES (NOT USED)

END OF SECTION
SECTION 16444
LOW VOLTAGE MOTOR CONTROL CENTERS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Low voltage motor control centers.

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

B. National Electrical Manufacturer's Association (NEMA):
   1. ICS 18-2001 - Motor Control Centers.

C. Underwriters Laboratories (UL):
   1. 845 - Motor Control Centers.

1.03 DEFINITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

A. Factory assembled, factory wired and factory tested motor control centers:
   1. Motor control centers and major components to be products of a single manufacturer.

1.05 SUBMITTALS

A. Furnish submittals as specified in General Conditions and 16050 - Common Work Results for Electrical.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

B. All portions of the motor control center, vertical bays, and components shall be UL listed and labeled:
   1. Where indicated as service entrance equipment, the motor control center shall be UL labeled and listed “Suitable for Service Entrance”.

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1.07 DELIVERY, STORAGE AND HANDLING
   A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS
   A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING
   A. Assemble equipment in the field.
   B. Conduct field acceptance test and submit results for Engineer’s review.
   C. Submit manufacturer’s certification that the equipment has been properly installed and is fully functional for Engineer’s review.
   D. Conduct District’s training sessions.
   E. Commissioning and process start-up as specified in Section 01756 - Commissioning.

1.10 SCHEDULING
   A. As specified in Section 16050 - Common Work Results for Electrical.

1.11 WARRANTY
   A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP
   A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 DISTRICT’S INSTRUCTION (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS (not used)

2.02 EXISTING PRODUCTS
   A. Existing motor control centers:
      1. Provide complete motor control center vertical sections or individual motor control center units to be added to existing motor control centers as specified in this Section and as indicated on the Drawings.
2. Provide additions that are of the same manufacturer, type, and electrical ratings as the existing motor control centers:
   a. Provide all hardware necessary to connect the busses of the new and existing motor control centers.
3. Provide enclosures to match the NEMA ratings and colors of the existing motor control centers.

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. General:
   1. Provide wire markers at each end of every wire as specified in Section 16075 - Identification for Electrical Systems.
   2. Provide devices or accessories not specified in this Section but necessary for the proper installation and operation of the equipment.

B. Design and construct motor control center to operate at the voltage level and configuration indicated on the Drawings.

2.06 COMPONENTS

A. Provide components contained within the motor control center as specified in:
   1. Section 16075 - Identification for Electrical Systems.
   2. Section 16123 - 600-Volt or Less Wires and Cables.
   3. Section 16150 - Low Voltage Wire Connections.
   4. Section 16412 - Low Voltage Molded Case Circuit Breakers.

2.07 ACCESSORIES

A. Wiring:
   1. Wire the motor control center in accordance with the following NEMA Class and Type as defined by NEMA ICS 18-2001:
      a. NEMA Class II-S:
         1) Furnish wiring diagrams for individual units consisting of drawings that identify electrical devices, electrical connections, and indicate terminal numbering designations.
         2) Furnish individual unit diagrams with each unit and include inter-wiring between units, i.e. electrical interlocking, etc., as specifically specified in the Contract Documents.
         3) Provide custom drawings with unique terminal numbering designations in lieu of standard manufacturer drawings.
      b. NEMA Type B wiring:
         1) Control wiring:
            a) Type B-T pull-apart terminal blocks.
2) Power wiring:
   a) Type B-T for Size 1 starters.
   b) Type B-T or B-D for Size 2 and 3 starters.
   c) Type B for Size 4 and larger starters and feeder units.

B. Lugs and terminals:
   1. For all external connections of No. 6 AWG wire or larger:
      a. UL listed for copper or aluminum conductors.
   2. Compression type, requiring a hydraulic press and die for installation.
   3. Provide 20 percent spare control block terminals.

C. Nameplates:
   1. Provide nameplates as specified in Section 16075 - Identification for Electrical Systems.
   2. Furnish individual nameplates for each unit indicated on the Drawings:
      a. 1 nameplate to identify the unit designation.
      b. 1 nameplate to identify the load served.
      c. Furnish space units with blank nameplates.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3    EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. General:
   1. Furnish all cables, conduit, lugs, bolts, sealants, and other accessories necessary to completely install for the line, load, and control connections.
   2. Furnish all components, and equipment necessary to complete the installation.
   3. Replace hardware, lost or damaged during installation or handling, in order to provide a complete installation.
C. Bundle circuits together and terminate in each unit:
   1. Tie with nylon wire ties as specified in Section 16123 - 600-Volt or Less Wires and Cables.
   2. Label all wires at each end with wire markers as specified in Section 16075 - Identification for Electrical Systems as shown on the approved elementary schematics.

3.04 ERECTION, INSTALLATION, APPLICATION CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 REINSTALLATION (NOT USED)

3.07 COMMISSIONING
   A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL
   A. As specified in Section 16050 - Common Work Results for Electrical.
   B. Provide the services of a manufacturer’s representative to:
      1. Inspect, verify, and certify that the motor control center installation meets the manufacturer’s requirements.

3.09 ADJUSTING
   A. Make all adjustments as necessary and recommended by the manufacturer, Engineer, or testing firm.

3.10 CLEANING
   A. As specified in Section 16050 - Common Work Results for Electrical.

3.11 PROTECTION
   A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION
PART 1  GENERAL

1.01  SUMMARY

   A. Section includes: LED luminaires, drivers, poles, and accessories.

1.02  REFERENCES

   A. As specified in Section 16050 - Common Work Results for Electrical.

   B. Illuminating Engineering Society of North America (IESNA):
      2. LM-80 - IES Approved Method: Measuring Lumen Maintenance of LED Light Sources.
      3. TM-21 - Projecting Long Term Lumen Maintenance of LED Light Sources.

   C. Institute of Electrical and Electronics Engineers (IEEE):

   D. National Electrical Manufacturers Association (NEMA):
      1. 410 - Performance Testing for Lighting Controls and Switching Devices with Electronic Drivers and Discharge Ballasts.

   E. Underwriters Laboratories (UL):
      1. 1598 - Luminaires.
      2. 8750 - Light Emitting Diode (LED) Equipment For Use In Lighting Products.

1.03  DEFINITIONS

   A. As specified in Section 16050 - Common Work Results for Electrical.

   B. Specific definitions and abbreviations:
      1. CCT: Correlated color temperature - Scientific scale to describe how “warm” or how “cool” the light source is, measured in Kelvin. The lower the Kelvin temperature, the warmer the light feels, or appears.
      2. CRI: Color Rendering Index - A quantitative measure of the ability of a light source to reveal the colors of various objects faithfully in comparison with an ideal or natural light source.
      3. Driver - Device that manages power and controls the current flow from AC to DC for an LED lighting product.
4. Efficacy - Lumen output of a light source per unit of power supplied to that source (lumens per watt).
5. EMI: Electromagnetic Interference - Electrical interference (noise) generated by electrical and electronic devices.
6. FC: Foot Candles - Measure of light level on a surface being illuminated.
7. L70 - The extrapolated life in hours of the luminaire when the luminous output depreciates 30 percent from initial values.
8. LED: Light emitting diode - A solid-state semiconductor device that produces light when electrical current flows through it.
9. LED light source - See LED luminaire.
10. LED luminaire - A complete lighting unit consisting of LED-based light emitting elements and a matched driver together with parts to distribute light, to position and protect the light emitting elements, and to connect the unit to a branch circuit.
11. Lumen - The international (SI) unit of luminous flux or quantity of light. The amount of light that is spread over a square foot of surface by one candle power when all parts of the surface are exactly one foot from the light source.
12. Lumen ambient temperature multiplier - LED light source relative lumen output when compared to a standard ambient temperature.
13. Lumen maintenance factor - How well an LED light source is able to retain its intensity when compared to new.
15. THD: Total harmonic distortion - The combined effect of harmonic Distortion on the AC waveform produced by a driver or other device.

1.04 SYSTEM DESCRIPTION

A. Provide luminaires, and accessories for all lighting systems, complete and operable, in accordance with the requirements of the Contract Documents.

B. Individual luminaire types are indicated on the Drawings and on the Luminaire Schedule.

1.05 SUBMITTALS

A. Furnish submittals as specified in General Conditions and Section 16050 - Common Work Results for Electrical.

B. Product data:
   1. LED Luminaires:
      a. Catalog literature for each luminaire specified, cross-referenced to the luminaire type on the Luminaire Schedule in the Drawings.
      b. Provide for each luminaire type:
         1) Materials.
         2) Type of diffuser.
         3) Hardware.
4) Gasketing.
5) Reflector.
6) Chassis.
7) Finish and color.
8) Driver type and protection.
9) LED luminaire:
   a) Initial lumen output at 40 degrees Celsius ambient.
   b) Correlated color temperature.
   c) Lumen maintenance factors.
   d) Lumen ambient temperature multipliers.
   e) Drive current.
   f) Efficacy.
10) Picture of luminaire.
11) Dimensioned drawings:
    a) Effective projected area rating for pole mounted luminaires.
12) Weight.
13) Photometric data:
    a) Coefficient of utilization tables based on the IES zonal cavity system by an approved testing laboratory.
    b) Luminaire dirt depreciation factor.
    c) Candlepower distribution curves.
    d) Average luminaire brightness.
    e) Lumen output charts.
14) Furnish support method for interior luminaires weighing more than 30 pounds and all wall-mounted luminaires:
    a) Support methods shall be based on seismic requirements at the project site as specified in Section 16050 - Common Work Results for Electrical.

c. Luminaire substitutions:
   1) Provide complete literature for each luminaire substitution:
   2) Submittals for substituted luminaires shall be sufficient for competent comparison of the proposed luminaire to the originally specified luminaire:
      a) Photometric data:
         (1) IES file in standard IES format.
         (2) Coefficient of utilization tables based on the IES zonal cavity system by an approved testing laboratory.
         (3) Candlepower distribution curves.
         (4) Average luminaire brightness.
         (5) Lumen output charts.
         (6) Power requirements in watts and volt-amperes.
      b) Calculations:
         (1) Provide software generated calculations showing illuminance levels in footcandles and power usage in watts.
per square foot for each of the areas in which substitutions are proposed:

(a) Use surface reflectance values and luminaire light loss factors approved by the Engineer to perform all calculations.

c) Specification sheets:

(1) If lacking sufficient detail to indicate compliance with contract documents, standard specification sheets will not be accepted. This includes, but is not limited to, luminaire type designation, manufacturer’s complete catalog number, voltage, LED type, CCT, CRI, specific driver information, system efficacy, L70 life rating, and any modifications necessary to meet the requirements of the contract documents.

3) Substitutions for specified luminaires will be evaluated upon quality of construction, light distribution, energy use, appearance, and maintenance.

4) Substitutions shall comply with all applicable building and energy codes.

2. Driver: Provide for each driver type:

a. Catalog number.

b. Type of driver.

c. Output wattage.

d. Input voltage.

e. Operating voltage range.

f. Maximum input power.

g. Efficiency.

h. Operating line current.

i. Power factor.

j. Operating temperature range.

k. Current output range in ambient temperatures of 30 to 55 degrees Celsius.

l. Surge suppression data.

3. Photocell:

a. Provide for each photocell type:

1) Switching capacity.

2) Life expectancy when used on LED sources.

3) The means of adjusting the lighting pickup level.

4) Enclosure type.

5) Mounting method.

4. Luminaire poles:

a. Submit complete data for each pole type including but not limited to:

1) Material.

2) Finish and color.

3) Handholes.
4) Anchoring.
5) Luminaire attachment methods and fittings.
6) Pole height.
7) Pole dimensions.
8) Bolt hole circle layout and hardware.
9) Accessories.
10) Provide the EPA wind load rating.

C. Calculations:
   1. Provide complete design calculations and installation documents for pole mounting piers and poles mounted from structures:
      a. Include in the calculations the wind and seismic requirements at the project site.
      b. Calculations and design shall be performed by and signed by a Professional Engineer registered in the state where the project is being constructed.

D. Record documents:
   1. Update the Luminaire Schedule in the Drawings to reflect the acceptable substitutions, after the substitution has been reviewed and accepted by the Engineer.

1.06 QUALITY ASSURANCE

   A. As specified in Section 16050 - Common Work Results for Electrical.

1.07 DELIVERY, STORAGE, AND HANDLING

   A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

   A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING

   A. Exterior and outdoor lighting system operation shall be demonstrated during the hours of darkness.

   B. Lighting demonstration shall occur within 2 weeks before substantial completion.

1.11 WARRANTY

   A. As specified in Section 16050 - Common Work Results for Electrical.
B. LED luminaire:
   1. 5 year warranty from the date of installation including material, workmanship, photometrics, driver, and LED modules.

1.12 SYSTEM START-UP

A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 DISTRICT’S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE

A. Furnish 1 complete spare LED luminaire, with driver, of each type used.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Luminaires:
   1. The following or equal:
      a. As noted on the Luminaire Schedule.

B. Drivers:
   1. One of the following or equal:
      a. Philips Advance.
      b. Thomas Research.
      c. eldoLED.

C. Photo-electric cells:
   1. One of the following or equal:
      a. Cooper.
      b. Tork.
      c. Intermatic.

D. Substitutions:
   1. The lighting design and luminaire selection has been based upon the photometric data of the identified luminaire. It is the Contractor’s responsibility to ensure and prove to the Engineer at time of submittal the substitutions meet the quality and photometric requirements of the original design.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)
2.05 EQUIPMENT

A. LED Luminaires:
   1. General:
      a. Pre-wired with leads of 18-AWG, minimum, for connection to building circuits.
      b. Provide the luminaires furnished per the Luminaire Schedule in the Drawings:
         1) The Specifications noted in this Section are an addition or supplement to the Luminaire Schedule.
      c. Individual LEDs connected such that a catastrophic loss or the failure of 1 LED will not result in the loss of the entire luminaire.
   2. Minimum ambient temperature range of 0 degrees Celsius to 40 degrees Celsius.
   3. Minimum rated life:
      a. Process Areas: 60,000 hours when operated at 40 degrees Celsius.
   4. Minimum efficacy of 70 lumens/watt.
   5. Minimum Color Rendering Index of 70.
   6. Tested according to IESNA LM-79 and LM-80.
   7. Lumen maintenance projection in accordance with IESNA TM-21.
   8. RoHS compliant.
   9. Integral driver.
   10. Suitable for dry, damp, or wet locations as on the Luminaire Schedule:
       a. Wet or damp locations: UL 1598 listed.
   11. Designed as a complete LED assembly. Retrofit LED lamps in luminaires not designed specifically for LED light sources shall not be used.
   12. Exterior/outdoor luminaires:
       a. Luminaires in combination with their mounting pole and bracket shall be capable of withstanding:
          1) Wind levels at the project site without damage.
          2) Seismic levels at the project site.
       b. Corrosion-resistant hardware and hinged doors or lens retainer.
       c. Luminaires furnished with integral photoelectrical control shall be of the luminaire manufacturer's standard design.
       d. California Energy Code Light Pollution Reduction Compliance:
          1) Provide all exterior luminaires with cutoff photometrics:
             a) Luminaire design shall allow no more than 0.01 horizontal footcandles to escape beyond the site boundary.

B. Photo-electric cells:
   1. Photoelectric cells for control of multiple luminaires:
      a. Self-contained.
      b. Weatherproof.
      c. Provided with time-delay features.
d. Sized to meet switching capacity of the circuit:
   1) Based on luminaire VA as indicated on the Drawings.

2. Photoelectric cell for control of a single luminaire:
   a. Integral to the luminaire.

C. Luminaire control:
   1. Lighting control relays or contactors as specified in Section 16422 - Motor Starters.

D. Drivers:
   1. Dimmable, with dimming signal protocol of 0-10 VDC or DALI.
   2. Input power source:
      a. As indicated on the Drawings.
   3. Drive current:
      a. As indicated in the Luminaire Schedule.
   4. Power factor: greater than 0.90.
   5. Efficiency: greater than 80 percent.
   6. Total harmonic distortion (THD) of the input current less than 20 percent.
   7. Rated life of 60,000 hours in an LED luminaire operated at an ambient temperature of 40 degrees Celsius.
   8. Minimum operating temperature of -40 degrees Celsius.
   9. Sound rating: Class A+ or quieter.
   10. UL listed Class 2 Outdoor in accordance with UL 8750.
   11. In accordance with IEEE C62.41 Category A for transient protection.
   12. Driver must limit inrush current:
       a. Meet or exceed NEMA 410 driver inrush standard:
          1) 230 Amps per 10 Amp load with a maximum of 106 Amps squared-seconds at 120V.
          2) 430 Amps per 10 Amp load with a maximum of 370 Amps squared-seconds at 277V.

2.06 COMPONENTS

A. Luminaire poles:
   1. As indicated on the Luminaire Schedule.
   2. Anchor bolts:
      a. Use anchor bolts, bolts, or welded studs for anchors for resisting seismic and wind forces:
         1) Standard hex bolt head.
         2) Do not use anchor bolts fabricated from rod stock with an L or J-shape.
      b. Complete with leveling shims.
   3. Anchor base:
      a. Fabricated from the same type of material as the pole shaft.
      b. Base plate to telescope the pole shaft.
      c. Welded top and bottom along the entire perimeter.
d. With slotted bolt holes on the bolt circles as submitted.

4. Pole shaft:
   a. As indicated on the Luminaire Schedule.

5. Handhole:
   a. Reinforced handhole located approximately 18 inches above the base.
   b. Complete with cover fabricated from the same material as the pole shaft and stainless steel attachment screws.
   c. With an integral ground connection nut, 1/2 inch by 13 inch UNC welded to the pole for connection to the grounding system.

6. Shroud:
   a. Fabricated from the same type of material as the pole shaft.
   b. 1-piece formed channel section that shall conform to the pole shaft taper.
   c. Secured by a locking device with provisions for a padlock to prevent accidental lowering.

7. Fastening hardware:
   a. All fasteners shall be stainless steel.

8. Finish:
   a. As indicated on the Luminaire Schedule.

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Install luminaires per the manufacturer’s guidelines and submitted installation calculations to meet seismic and wind requirements at the project site.

C. Special techniques:
   1. Support luminaires from structural elements capable of carrying the total weight.
2. In all cases, coordinate luminaire locations with work of other trades to prevent obstruction of light from the fixtures:
   a. Locate bottom of luminaire approximately at the bottom of ductwork, unless otherwise specified or indicated on the Drawings.

D. Luminaire poles:
   1. Set poles on anchor bolts and secured with double nuts on each bolt.
   2. Dry-pack the pole base, after the luminaire and pole has been leveled and plumbed.
   3. Bond metal poles to the plant grounding system, utilizing a ground lug connection within the pole:
      a. Route ground conductor through pier and pole base sleeve using Schedule 40 PVC conduit.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING
   A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL
   A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING
   A. Aim and verify all exterior and outdoor luminaires alignment, during dark evening hours, as directed by District or the Engineer.

3.10 CLEANING
   A. As specified in Section 16050 - Common Work Results for Electrical.
   B. Clean all lenses, diffusers, and reflectors.
   C. Refinish all luminaires’ trim, poles, and support brackets, where finish has been damaged.
   D. Clean all LED luminaires (new and old), used during construction for construction lighting, before substantial completion.
   E. Clean and re-lamp all existing fluorescent and HID luminaires used during construction for construction lighting, before substantial completion.
3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES

A. Refer to the Luminaire Schedule in the Drawings.

END OF SECTION
SECTION 16950

FIELD ELECTRICAL ACCEPTANCE TESTS

PART 1  GENERAL

1.01  SUMMARY

A.  Section includes:
   1. Responsibilities for testing the electrical installation.
   2. Adjusting and calibration.
   3. Acceptance tests.

B.  Copyright information:
   1. Some portions of this Section are copyrighted by the InterNational Electrical Testing Association, Inc. (NETA). See NETA publication ATS for details.

1.02  REFERENCES

A.  As specified in Section 16050 - Common Work Results for Electrical.

B.  American National Standards Institute (ANSI).

C.  ASTM International (ASTM):
   3. D924 - Standard Test Method for Dissipation Factor (or Power Factor) and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids.
   5. D974 - Standard Test Method for Acid and Base Number by Color-Indicator Titration.
D. Institute of Electrical and Electronics Engineers (IEEE):
1. 43 - IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machinery.
3. 95 - IEEE Recommended Practice for Insulation Testing of AC Electric Machinery (2300 V and Above) With High Direct Voltage.

E. Insulated Cable Engineer’s Association (ICEA).

F. InterNational Electrical Testing Association (NETA):


H. Manufacturer’s testing recommendations and instruction manuals.

I. National Fire Protection Association (NFPA):
1. 70 - National Electrical Code (NEC).

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

K. Specification sections for the electrical equipment being tested.

L. Shop drawings.

1.03 DEFINITIONS

A. As specified in Sections 01756 - Commissioning and 16050 - Common Work Results for Electrical.
B. Specific definitions:
   1. Testing laboratory: The organization performing acceptance tests.

1.04 SYSTEM DESCRIPTION

A. Testing of all electrical equipment installed under this Contract in accordance with the manufacturer’s requirements and as specified in this Section.

B. Conduct all tests in the presence of the Engineer or the Engineer’s representative:
   1. Engineer will witness all visual, mechanical, and electrical tests, and inspections.

C. The testing and inspections shall verify that the equipment is operational within the tolerances required and expected by the manufacturer, and these Specifications.

D. Responsibilities:
   1. Contractor responsibilities:
      a. Ensure that all resources are made available for testing, and that all testing requirements are met.
   2. Electrical subcontractor responsibilities:
      a. Perform routine tests during installation.
      b. Demonstrate operation of electrical equipment.
      c. Commission the electrical installation.
      d. Provide the necessary services during testing, and provide these services to the testing laboratory, Contractor, and other subcontractors, including but not limited to:
         1) Providing electrical power as required.
         2) Operating of electrical equipment in conjunction with testing of other equipment.
         3) Activating and shutting down electrical circuits.
         4) Making and recording electrical measurements.
         5) Replacing blown fuses.
         6) Installing temporary jumpers.
   3. Testing laboratory responsibilities:
      a. Perform all acceptance tests specified in this Section.
      b. Provide all required equipment, materials, labor, and technical support during acceptance tests.

1.05 SUBMITTALS

A. Furnish submittals as specified in General Conditions and 16050 - Common Work Results for Electrical.

B. Manufacturers’ testing procedures:
   1. Submit manufacturers’ recommended testing procedures and acceptable test results for review by the Engineer prior to beginning testing.
C. Test report:
   1. Include the following:
      a. Summary of Project.
      b. Description of equipment tested.
      c. Description of tests performed.
      d. Test results.
      e. Conclusions and recommendations.
      f. Completed test forms.
      g. List of test equipment used and calibration dates.
      h. LAN cable test reports.

D. Test data records:
   1. Include the following:
      a. Identification of the testing organization.
      b. Equipment identification.
      c. Nameplate data.
      d. Humidity, temperature and or other conditions that may affect the results of the tests and or calibrations.
      e. Dates of inspections, tests, maintenance and or calibrations.
      f. Indication of the inspections, tests, maintenance, and or calibrations to be performed and recorded.
      g. Expected results when calibrations are to be performed.
      h. Indication of as-found and as-left results as applicable.
      i. Indication of all test results outside specified tolerances.

E. Testing laboratory qualifications:
   1. Submit a complete resume and statement of qualifications from the proposed testing laboratory detailing their experiences in performing the tests specified:
      a. This statement will be used to determine whether the laboratory is acceptable, and shall include:
         1) Corporate history and references.
         2) Resume of individual performing test.
         3) Equipment list and test calibration data.

F. Division of responsibilities:
   1. Submit a list identifying who is responsible for performing each portion of the testing.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Testing laboratory qualifications:
   1. The testing laboratory may be qualified testing personnel from the electrical subcontractor's staff or an independent testing company.
   2. NETA certification required.
3. Selection of the testing laboratory and testing personnel is subject to approval by the Engineer based on testing experience and certifications of the individuals and testing capabilities of the organization.

1.07 DELIVERY, STORAGE, AND PROTECTION (NOT USED)

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING

A. At least 30 days before commencement of the acceptance tests, submit the manufacturer’s complete field testing procedures to the Engineer and to the testing laboratory, complete with expected test results and tolerances for all equipment to be tested.

B. Perform testing in the following sequence:
   1. Perform routine tests as the equipment is installed including:
      a. Insulation-resistance tests.
      b. Continuity tests.
      c. Rotational tests.
   2. Adjusting and preliminary calibration.
   3. Acceptance tests.
   4. Demonstration.
   5. Commissioning and plant start-up.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP (NOT USED)

1.13 DISTRICT'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)
3.02 PREPARATION

A. Test instrument calibration:
   1. Utilize a testing laboratory with a calibration program which maintains all applicable test instrumentation within rated accuracy:
      a. The calibrating standard shall be of better accuracy than that of the equipment tested.
   2. The accuracy shall be traceable to the NIST in an unbroken chain.
   3. Calibrate instruments in accordance with the following frequency schedule:
      a. Field instruments: 6 months maximum.
      b. Laboratory instruments: 12 months maximum.
      c. Leased specialty equipment where the accuracy is guaranteed by the lessor (such as Doble): 12 months maximum.
   4. Dated calibration labels shall be visible on all test equipment.
   5. Maintain an up-to-date instrument calibration record for each test instrument:
      a. The records shall show the date and results of each calibration or test.
   6. Maintain an up-to-date instrument calibration instruction and procedure for each test instrument.

B. Do not begin testing until the following conditions have been met:
   1. All instruments required are available and in proper operating condition.
   2. All required dispensable materials such as solvents, rags, and brushes are available.
   3. All equipment handling devices such as cranes, vehicles, chain falls and other lifting equipment are available or scheduled.
   4. All instruction books, calibration curves, or other printed material to cover the electrical devices are available.
   5. Data sheets to record all test results are available.

3.03 INSTALLATION

A. Test decal:
   1. The testing laboratory shall affix a test decal on the exterior of equipment or equipment enclosure of protective devices after performing electrical tests.
   2. The test decal shall be color coded to communicate the condition of maintenance of the protective. The color scheme for condition of maintenance of overcurrent protective devices shall be:
      a. White: electrically and mechanically acceptable.
      b. Yellow; minor deficiency not affecting fault detection and operation, but minor electrical or mechanical condition exists.
   3. The decal shall include the following information at a minimum:
      a. Testing organization.
      b. Project identifier.
      c. Test date.
      d. Technician identifier.
3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Testing and Training Phase: Installation Testing:
   1. Also called "Field Acceptance Testing."
   2. Low voltage cables, 600 volt maximum:
      a. Visual and mechanical inspection:
         1) Compare cable data with the Drawings and Specifications.
         2) Inspect exposed sections of cable for physical damage and correct connection as indicated on the Drawings.
         3) Inspect bolted electrical connections for high resistance by one of the following methods:
            a) Use of low-resistance ohmmeter.
            b) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
               (1) Refer to manufacturer’s instructions for proper foot-pound levels or NETA ATS tables.
         4) Inspect compression applied connectors for correct cable match and indentation.
         5) Inspect for correct identification and arrangement.
         6) Inspect cable jacket insulation and condition.
      b. Electrical tests:
         1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
         2) Perform insulation resistance test on each conductor with respect to ground and adjacent conductors:
            a) Applied potential shall be 500 volts dc for 300 volt rated cable and 1,000 volts dc for 600 volt rated cable.
            b) Test duration shall be 1 minute.
         3) Perform continuity tests to insure correct cable connection.
         4) Verify uniform resistance of parallel conductors.
      c. Test values:
         1) Compare bolted connection resistance values to values of similar connections:
            a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2) Insulation-resistance values shall be in accordance with manufacturer’s published data:
   a) Refer to NETA ATS tables in the absence of manufacturer’s published data.
   b) Investigate values of insulation-resistance less than the allowable minimum.
3) Cable shall exhibit continuity.
4) Deviations in resistance between parallel conductors shall be investigated.

3. Low voltage molded case breakers:
   a. Visual and mechanical inspection:
      1) Compare equipment nameplate data with the Contract Documents.
      2) Inspect physical and mechanical condition.
      3) Inspect anchorage and alignment.
      4) Verify the unit is clean.
      5) Operate the circuit breaker to ensure smooth operation.
      6) Inspect bolted electrical connections for high resistance by one of the following methods:
         a) Use of low-resistance ohmmeter.
         b) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
            (1) Refer to manufacturer’s instructions for proper foot-pound levels or NETA ATS tables.
      7) Perform adjustments for final protective device settings in accordance with the coordination study.
   b. Electrical tests:
      1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
      2) Perform insulation-resistance tests for 1 minute on each pole, phase-to-phase and phase-to-ground with the circuit breaker closed and across each open pole:
         a) Apply voltage in accordance with manufacturer’s published data.
         b) Refer to NETA ATS tables in the absence of manufacturer’s published data.
      3) Perform a contact/pole-resistance test.
      4) Determine long-time pickup and delay by primary current injection.
      5) Determine short-time pickup and delay by primary current injection.
      6) Determine ground-fault pickup and delay by primary current injection.
      7) Determine instantaneous pickup value by primary current injection.
      8) Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer’s published data.
      9) Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip
operation, trip-free, anti-pump function and trip unit battery condition:

a) Reset all trip logs and indicators.

10) Verify operation of charging mechanism.

c. Test values:

1) Compare bolted connection resistance values to values of similar connections:
   a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.

2) Bolt-torque levels shall be in accordance with manufacturer’s published data:
   a) Refer to NETA ATS tables in the absence of manufacturer’s published data.

3) Insulation-resistance values shall be in accordance with manufacturer’s published data:
   a) Refer to NETA ATS tables in the absence of manufacturer’s published data.
   b) Investigate values of insulation-resistance less than the allowable minimum.

4) Microhm or dc millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer’s published data:
   a) If manufacturer’s data is not available, investigate any values which deviate from adjacent poles or similar breakers by more than 50 percent of the lowest value.

5) Long-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer’s published time-current characteristic tolerance band including adjustment factors:
   a) If manufacturer’s curves are not available, trip times shall not exceed the value shown in NETA ATS tables.

6) Short-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer’s published time-current tolerance band.

7) Ground fault pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer’s published time-current tolerance band.

8) Instantaneous pickup values shall be as specified and within manufacturer’s published tolerances:
   a) Refer to NETA ATS tables in the absence of manufacturer’s published data.

9) Pickup values and trip characteristics shall be within manufacturer’s published tolerances.

10) Breaker open, close, trip, trip-free, anti-pump, and auxiliary features shall function as designed.
11) The charging mechanism shall operate in accordance with manufacturer’s published data.

4. Grounding systems:
   a. Visual and mechanical inspection:
      1) Inspect ground system for compliance with the Contract Documents, and the NEC.
      2) Inspect physical and mechanical condition.
      3) Inspect bolted electrical connections for high resistance using one of the following methods:
         a) Use of low-resistance ohmmeter.
         b) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
            (1) Refer to manufacturer’s instructions for proper foot-pound levels or NETA ATS tables.
      4) Inspect anchorage.
   b. Electrical tests:
      1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
      2) Perform fall of potential test or alternative test in accordance with IEEE 81 on the main grounding electrode or system.
      3) Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, the system neutral and any derived neutral points.
   c. Test values:
      1) Grounding system electrical and mechanical connections shall be free of corrosion.
      2) Compare bolted connection resistance values to values of similar connections:
         a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
      3) Bolt-torque levels shall be in accordance with manufacturer’s published data:
         a) Refer to NETA ATS tables in the absence of manufacturer’s published data.
      4) The resistance between the main grounding electrode and ground shall be as specified in Section 16060 - Grounding and Bonding.
      5) Investigate point-to-point resistance values that exceed 0.5 ohm.

5. Motor starters, low voltage:
   a. Visual and mechanical inspection:
      1) Compare equipment nameplate information with the Contract Documents.
      2) Inspect physical and mechanical condition.
      3) Inspect anchorage, alignment, and grounding.
      4) Verify the unit is clean.
5) Inspect contactors:
   a) Verify mechanical operation.
   b) Verify contact gap, wipe, alignment, and pressure is in accordance with manufacturer’s published data.

6) Motor-running protection:
   a) Verify overload element rating/motor protection settings are correct for its application.
   b) If motor running protection is provided by fuses, verify correct fuse rating.

7) Inspect bolted electrical connections for high resistance using one of the following methods:
   a) Use of low-resistance ohmmeter.
   b) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
      (1) Refer to manufacturer’s instructions for proper foot-pound levels or NETA ATS tables.

8) Lubrication requirements:
   a) Verify appropriate lubrication on moving current-carrying parts.
   b) Verify appropriate lubrication on moving and sliding surfaces.

b. Electrical tests:
   1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
   2) Perform insulation-resistance tests for 1 minute on each pole, phase-to-phase and phase to ground with the starter closed, and across each open pole for 1 minute:
      a) Test voltage shall be in accordance with manufacturer’s published data.
      b) Refer to NETA ATS tables in the absence of manufacturer’s published data.
   3) Test motor protection devices in accordance with manufacturer’s published data.
   4) Test circuit breakers as specified in this Section.
   5) Perform operational tests by initiating control devices.

   c. Test values:
      1) Compare bolted connection resistance values to values of similar connections:
         a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
      2) Bolt-torque levels shall be in accordance with manufacturer’s published data:
         a) Refer to NETA ATS tables in the absence of manufacturer’s published data.
3) Insulation-resistance values shall be in accordance with manufacturer’s published data:
   a) Refer to NETA ATS tables in the absence of manufacturer’s published data.
   b) Investigate values of insulation-resistance less than the allowable minimum.
4) Motor protection parameters shall be in accordance with manufacturer’s published data.
5) Circuit breaker test results shall as specified in this Section.
6) Control devices shall perform in accordance with system design requirements.

6. Switches:
   a. Visual and mechanical inspection:
      1) Compare equipment nameplate data with the Contract Document.
      2) Inspect physical and mechanical condition.
      3) Inspect anchorage, alignment, grounding, and required clearances.
      4) Verify the unit is clean.
      5) Verify correct blade alignment, blade penetration, travel stops, and mechanical operation.
      6) Verify that fuse sizes and types as indicated on the Drawings, short-circuit studies, and coordination study.
      7) Verify that each fuse has adequate mechanical support and contact integrity.
      8) Inspect bolted electrical connections for high resistance using one of the following methods:
         a) Use of a low resistance ohmmeter.
         b) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
            (1) Refer to manufacturer’s instructions for proper foot-pound levels or NETA ATS tables.
      9) Verify operation and sequencing of interlocking systems.
     10) Verify correct phase barrier installation.
     11) Verify correct operation of all indicating and control devices.
     12) Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
   b. Electrical tests:
      1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
      2) Measure contact resistance across each switchblade and fuseholder.
      3) Perform insulation-resistance tests for 1 minute on each pole, phase-to-phase and phase-to ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer’s published data:
         a) In the absence of manufacturer’s published data, use NETA ATS requirements.
4) Measure fuse resistance.
5) Verify cubicle space heater operation.
6) Perform ground fault test as specified in this Section, if applicable.
7) Perform tests on other protective devices as specified in this Section, if applicable.

c. Test values:
1) Compare bolted connection resistance values to values of similar connections:
   a) Investigate values which deviate from those of similar bolted connection by more than 50 percent of the lowest value.
2) Bolt-torque levels shall be in accordance with manufacturer’s published data:
   a) Refer to NETA ATS tables in the absence of manufacturer’s published data.

   d. Test values - electrical:
1) Compare bolted connection resistance values to values of similar connections:
   a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2) Microhm or dc millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer’s published data:
   a) If manufacturer’s published data is not available, investigate values which deviate from those of similar bus connections and sections by more than 50 percent of the lowest value.
3) Insulation-resistance values shall be in accordance with manufacturer’s published data:
   a) Refer to NETA ATS tables in the absence of manufacturer’s published data.
   b) Investigate insulation values less than the allowable minimum.
4) Investigate fuse-resistance values that deviate from each other by more than 15 percent.
5) Heaters shall be operational.
6) Ground fault tests shall be as specified in this Section.
7) Results of protective device tests shall be as specified in this Section.

3.08 FIELD QUALITY CONTROL (NOT USED)

3.09 ADJUSTING (NOT USED)

3.10 CLEANING

A. As specified in Section 16050 - Common Work Results for Electrical.

B. After the acceptance tests have been completed, dispose of all testing expendables, vacuum all cabinets, and sweep clean all surrounding areas.
3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION
SECTION 17050
COMMON WORK RESULTS FOR PROCESS CONTROL AND INSTRUMENTATION SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. General requirements applicable to all Process Control and Instrumentation Work.
   2. General requirements for process control and instrumentation submittals.
   3. As specified in this Section, PLC programming and SCADA/HMI software configuration will be provided by the Contractor per special conditions, hereinafter referred to as the Programmer.

B. Interfaces to equipment, instruments, and other components:
   1. Drawings, Specifications, and overall design are based on preliminary information furnished by various equipment manufacturers, which identify a minimum scope of supply from the manufacturers. This information pertains to, but is not limited to, instruments, control devices, electrical equipment, packaged mechanical systems, and control equipment provided with mechanical systems.
   2. Provide all material and labor needed to install the actual equipment furnished, include all costs to add any additional instruments, wiring, control system inputs/outputs, controls, interlocks, electrical hardware etc., which may be necessary to make a complete, functional installation based on the actual equipment furnished:
      a. Make all changes necessary to meet the manufacturer’s wiring requirements.
   3. Submit all such changes and additions to the Engineer for acceptance as specified in General Conditions.
   4. Review the complete set of Drawings and Specifications in order to ensure that all items related to the instrumentation and control systems are completely accounted for. Include any items indicated on the Drawings or in Specifications from another discipline in the scope of Work:
      a. If a conflict between Drawings and Specifications is discovered, refer conflict to the Engineer as soon as possible for resolution.
   5. Loop drawings:
      a. Provide complete loop drawings for all systems, including packaged equipment furnished as part of a vendor-furnished package, and for all pre-purchased equipment.
b. The form, minimum level of detail, and format for the loop drawings must match that of the sample loop drawings included in the Contract Documents.
c. The District and Engineer are not responsible for providing detailed loop diagrams for Contractor furnished equipment.

C. All instrumentation, and control equipment and systems for the entire project to comply with the requirements specified in the Instrumentation and Control Specifications, whether referenced in the individual Equipment Specifications or not:
   1. The requirements of the Instrumentation and Control Specifications apply to all Instrumentation and Control Work specified in other Specifications, including HVAC controls, packaged mechanical systems, LCPs, VCPs, etc.
   2. Inform all vendors supplying instrumentation, control systems, panels, and/or equipment of the requirements of the Instrumentation and Control Specifications.
   3. The District is not responsible for any additional costs due to the failure of the Contractor to notify all subcontractors and suppliers of the Instrumentation and Control Specifications’ requirements.

D. Contract Documents:
   1. General:
      a. The drawings and specifications are complementary and are to be used together in order to fully describe the Work.
   2. Specifications:
      b. These requirements are in addition to all General Requirements.
   3. Contract drawings:
      a. The Instrumentation and Control Drawings show in a diagrammatic manner, the desired locations, and arrangements of the components of the Instrumentation Work. Follow the drawings as closely as possible, use professional judgment and coordinate with the other trades to secure the best possible installation, use the entire drawing set for construction purposes.
      b. Locations of equipment, control devices, instruments, boxes, panels, etc. are approximate only, exercise professional judgment in executing the Work to ensure the best possible installation:
         1) The equipment locations and dimensions indicated on the Drawings and elevations are approximate. Use the shop drawings to determine the proper layout, foundation, and pad requirements, etc. for final installation. Coordinate with all subcontractors to ensure that all instrumentation and control equipment is compatible with other equipment and space requirements. Make changes required to accommodate differences in equipment dimensions.
2) The Contractor has the freedom to select any of the named manufacturers as identified in the individual Specifications; however, the Engineer has designed the spatial equipment layout based upon a single manufacturer and has not confirmed that every named manufacturer’s equipment fits in the allotted space. It is the Contractor’s responsibility to ensure that the equipment being furnished fits within the defined space.

c. Installation details:
   1) The Contract Drawings include installation details showing means and methods for installing instrumentation and control equipment. For cases where typical details are not provided or compatible with an installed location, develop installation details that are necessary for completing the Work, and submit these details for review by the Engineer.

d. Schematic diagrams:
   1) All controls are shown de-energized.
   2) Schematic diagrams show control function only. Incorporate other necessary functions for proper operation and protection of the system.
   3) Add slave relays, where required, to provide all necessary contacts for the control system or where needed to function as interposing relays for control voltage coordination, equipment coordination, or control system voltage drop considerations.
   4) Mount all devices shown on motor controller schematic diagrams in the controller compartment enclosure, unless otherwise noted or indicated.
   5) Control schematics are to be used as a guide in conjunction with the descriptive operating sequences indicated on the Drawings or in the Specifications. Combine all information and furnish a coordinated and fully functional control system.

E. Alternates/Alternatives:
   1. Substitute item provisions as specified in Document SC1 - Special Conditions.

F. Changes and change orders:
   1. As specified in Section 01600 - Product Requirements.

1.02 REFERENCES

A. Code compliance:
   1. As specified in Section 01410 - Regulatory Requirements:
      a. The publications are referred to in the text by basic designation only. The latest edition accepted by the Authority Having Jurisdiction of referenced publications in effect at the time of Bid governs.
   2. The following codes and standards are hereby incorporated into this Section:
b. International Society of Automation (ISA):
   1)  5.1 - Instrumentation Symbols and Identification.
   2)  5.4 - Instrument Loop Diagrams.
   3)  20 - Specification Forms for Process Measurement and Control
       Instruments, Primary Elements, and Control Valves.

c. National Electrical Manufacturers Association (NEMA):
   1)  250 - Enclosures for Electrical Equipment (1000 V Maximum).


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

f. Underwriters Laboratories, Inc. (UL):
   1)  508 - Standard of Safety for Industrial Control Equipment.
   2)  508A - Standard of Safety for Industrial Control Panels.

B. Compliance with Laws and Regulations:
   1. As specified in Contract Documents.

1.03 DEFINITIONS

A. Definitions of terms and other electrical and instrumentation considerations in
   accordance with:
   1. Factory Mutual (FM).
   3. Institute of Electrical and Electronics Engineers (IEEE).
   8. InterNational Electrical Testing Association (NETA).
  11. Underwriters Laboratories (UL).

B. Specific definitions:
   1. Control circuit: Any circuit operating at 120 volts alternating current (VAC) or
direct current (VDC) or less, whose principal purpose is the conveyance of
information (including performing logic) and not the conveyance of energy for
the operation of an electrically powered device.
   2. Panel: An instrument support system that may be a flat surface, a partial
enclosure, or a complete enclosure for instruments and other devices used in
process control systems.
   3. Power circuit: Any circuit operating at 90 volts (AC or DC) or more, whose
principal purpose is the conveyance of energy for the operation of an
electrically powered device.
   4. Signal circuit: Any circuit operating at less than 50 VAC or VDC, which conveys
analog information or digital communications information.
5. Digital bus: A communication network, such as PROFIBUS, Foundation Fieldbus, or DeviceNet, allowing instruments and devices to transmit data, control functions, and diagnostic information.

6. 2-Wire transmitter (loop powered): A transmitter that derives its operating power supply from the signal transmission circuit and requires no separate power supply connections. As used in this Section, 2-wire transmitter refers to a transmitter that provides a signal such as 4 to 20 mA 24VDC regulation of a signal in a series circuit with an external 24 VDC driving potential:
a. Fieldbus communications signal or both.

7. Powered transmitters: A transmitter that requires a separate power source (120 VAC, 240 VAC, etc.) in order for the transmitter to develop its signal. As used in this Section, the produced signal may be a 4 to 20 mA 24VDC signal, a digital bus communications signal, or both.

8. System supplier - As specified in ICSC Qualifications in the Quality Assurance article of this Section.

C. NEMA:
1. Type 1 enclosure in accordance with NEMA 250.
2. Type 2 enclosure in accordance with NEMA 250.
3. Type 3 enclosure in accordance with NEMA 250.
4. Type 3R enclosure in accordance with NEMA 250.
5. Type 3S enclosure in accordance with NEMA 250.
6. Type 3X enclosure in accordance with NEMA 250.
7. Type 3RX enclosure in accordance with NEMA 250.
8. Type 3SX enclosure in accordance with NEMA 250.
9. Type 4 enclosure in accordance with NEMA 250.
10. Type 4X enclosure in accordance with NEMA 250.
11. Type 5 enclosure in accordance with NEMA 250.
12. Type 6 enclosure in accordance with NEMA 250.
13. Type 6P enclosure in accordance with NEMA 250.
14. Type 12 enclosure in accordance with NEMA 250.
15. Type 12K enclosure in accordance with NEMA 250.
16. Type 13 enclosure in accordance with NEMA 250.

D. Acronym definitions:
1. ACB: Automatic current balance.
2. ATS: Automatic Transfer Switch.
3. CCS: The PCS central computer system (CCS) consisting of computers and software. The personal computer-based hardware and software system that includes the operator interface, data storage, data retrieval, archiving, alarming, historian, reports, trending, and other higher level control system software and functions.
4. DPDT: Double-pole, double-throw.
5. ES: Enterprise system: Computer based communications or data sharing system utilized for non-process control functions such as E-mail, sharing files, creating documents, etc.
6. FAT: Factory acceptance test also known as Source Test.
7. HART: Highway addressable remote transducer.
8. HOA: Hand-Off-Auto control function that is totally PLC based. In the Hand mode, equipment is started or stopped, valves are opened or closed through operator direction under the control of the PLC software. In the Auto mode, equipment is started or stopped and valves are opened or closed through a control algorithm within the PLC software. In the Off mode, the equipment is prohibited from responding from the PLC control.
9. HMI: Human machine interface is a software application that presents information to an operator or user about the state of a process, and to accept and implement the operators control instructions. Typically information is displayed in a graphical format.
10. ICSC: Instrumentation and control system contractor: Subcontractor who specializes in the design, construction, fabrication, software development, installation, testing, and commissioning of industrial instrumentation and control systems.
11. IJB: Instrument junction boxes: A panel designed with cord sets to easily remove, replace, or relocate instrument signals.
13. IP: Internet protocol or ingress protection.
14. LCP: Local control panel: Operator interface panel that may contain an HMI, pilot type control devices, operator interface devices, control relays, etc. and does not contain a PLC or RIO.
15. LAN: Local area network: A control or communications network that is limited to the physical boundaries of the facility.
16. LOI: Local Operator Interface is an operator interface device consisting of an alphanumeric or graphic display with operator input functionality. The LOI is typically a flat panel type of display mounted on the front of an enclosure with either a touch screen or tactile button interface.
17. LOR: Local-Off-Remote control function. In the Remote mode, equipment is started or stopped, and valves are opened or closed through the PLC based upon the selection of the HOA. In the Local mode, equipment is started or stopped, valves are opened or closed based upon hardwired control circuits completely independent of the PLC with minimum interlocks and permissive conditions. In the Off mode, the equipment is prohibited from responding to any control commands.
18. NJB: Network junction box. An enclosure that contains multiple access points to various networks within the facility. Networks could be Ethernet, Ethernet/IP, Fieldbus, RIO, etc.
20. PC: Personal computer.
21. PCIS: Process control and instrumentation system: Includes the entire instrumentation system, the entire control system, and all of the Work specified in the Instrumentation and Control Specifications and depicted on the Instrumentation Drawings. This includes all the PCS and instruments and networking components as well as the various servers, workstations, thin clients, etc.

22. PCM: Process control module: An enclosure containing any of the following devices: PLC, RTU, or RIO.

23. PCS: Process Control System: A general name for the computerized system that gathers and processes data from equipment and sensors and applies operational controls to the process equipment. It includes the PLCs and/or RIOs, LOIs, HMIs, both LCPs, VCPs and all data management systems accessible to staff.

24. PJB: Power junction box: An enclosure with terminal blocks that distribute power to multiple instruments.

25. PLC: Programmable logic controller.

26. PS: Power supply.

27. RIO: Remote I/O device for the PLC consisting of remote I/O racks, or remote I/O blocks.

28. RTU: Remote telemetry unit: A controller typically consisting of a PLC, and a means for remote communications. The remote communications devices typically are radios, modems, etc.

29. SCADA: Supervisory control and data acquisition system: A general name for the computerized system that gathers and processes data from sensors and equipment located outside of the facility, such as wells, lift stations, metering stations, etc.


32. UPS: Uninterruptible power supply.

33. VCP: Vendor control panel: Control panels that are furnished with particular equipment by a vendor other than the ICSC. These panels may contain PLCs, RIO, LOI, HMI, etc.

34. WAN: Wide area network: A control or communications network that extends beyond the physical boundaries of the facility.

1.04 SYSTEM DESCRIPTION

A. General requirements:

1. The Work includes everything necessary for and incidental to executing and completing the instrumentation and control system work indicated on the Drawings and specified in the Specifications and reasonably inferable there from including but not limited to:

   a. Preparing hardware submittals for field instrumentation.
b. Design, develop, and draft loop drawings, control panel designs, and all other drawing submittals specified in the Instrumentation and Control Specifications.
c. Prepare the test plan, the training plan, and the spare parts submittals.
d. Procure all hardware.
e. Provide all PCS system hardware excluding required Allen-Bradley PLC-5 IO modules to be installed in existing PLC/RIO panels.
f. Fabricate panels.
g. Perform factory tests on panels.
h. Perform bench calibration and verify calibration after installation.
i. Oversee and certify installation of the PCS system.
j. Oversee, document, and certify loop testing.
k. Oversee, document, and certify system.
l. Installation Testing.
m. Oversee and document Functional Testing.
o. Prepare operation and maintenance manuals.
p. Conduct training classes.
q. Integrate the PCS with instrumentation and control devices provided under other sections.
r. Provide Record Drawings and Loop Drawings associated with Instruments and equipment:
   1) As specified in the Contract Documents.
   2) For District-furnished items.
   3) For interfaces with existing equipment.
s. Resolve signal, power, or functional incompatibilities between the PCS and interfacing devices.
t. Perform all required corrective and preventative maintenance.

2. It is the intent of these Specifications that the entire electrical power, instrumentation, and control system be complete and operable. Provide all necessary material and labor for the complete system from source of power to final utilization equipment, including all connections, testing, calibration of all equipment furnished by others, as well as equipment furnished by the Contractor, whether or not specifically mentioned but which are necessary for successful operation.

3. Provide the complete operating PCS to perform the specified monitoring, communications, alarm, control, display, and reporting functions in accordance with the PCS requirements.

4. The Contractor, through the services of the Programmer, will provide the configuration and programming for parts of the PLC and PC based control system, as described below.
   a. The following PLCs will be programmed by the Programmer:
      1) PLC-12.
      2) PLC-13.
b. The CCS consisting of personal computers and software that will be configured by the Programmer.

c. All other PLCs and other programmable devices shall be programmed by the Contractor, either directly or through the services of other entities such as subcontractors, equipment suppliers, and packaged equipment suppliers (vendors).

d. The Programmer will assist with the testing of the software provided by the Programmer, as specified in this Section and in Section 17950 - Testing, Calibration, and Commissioning.

e. Programming of Vendor package control systems will be the responsibility of the Contractor and/or Vendor.

5. The Contractor, through the Programmer, will also supply miscellaneous hardware listed below. The hardware listed is for incorporation into the Plant PCS system, does not include all required PCS components, and will not be available for use in any other systems or equipment. The quantities being supplied by the Contractor are limited to the quantities listed below. Additional hardware shall be provided by the Contractor, as needed to complete the PCS system and all other portions of the Work shown or specified. Contractor will supply:

   1) To be installed in existing RIO-12A.

6. Coordinate all aspects of the Work between Contractor and all subcontractors before bidding to ensure that all costs associated with a complete installation are included. The District is not responsible for any change orders due to lack of coordination of the Work between the Contractor, the ICSC, the other subcontractors, or suppliers.

7. Furnish detailed, complete, and thorough operations and maintenance documentation, including but not limited to operations manuals, maintenance manuals, as-built wiring drawings, training manuals, as-built software documentation, and all other documentation required to operate, modify, and maintain all parts of the PCS.

8. The Programmer will provide as-built software documentation for the PLCs and computers programmed by the Programmer. The Programmer will provide training on hardware and software items provided by the Programmer. All other documentation and training shall be by the Contractor.

9. Portions of this Project involve installation in existing facilities and interfaces to existing circuits, power systems, controls, and equipment.

a. Perform and document comprehensive and detailed field investigations of existing conditions (circuits, power systems, controls, equipment, etc.) before performing any Work.

b. Provide and document interface with, modifications to, upgrade, or replacement of existing circuits, power systems, controls, and equipment.

10. Revise in a manner as directed by the Engineer all I/O and addressing that the Engineer determines to be unacceptable as a result of a lack of Contractor coordination between Contract Documents and all suppliers.
11. **Defective Work:**
   a. As specified in General Conditions.

B. **New system:**
   1. A new two pump Vendor Package pump station will be installed to transfer storm water to a new Out Of Compliance Pond. The controls for the vendor package will include a vendor provided control panel and instruments. A level transmitter will provide level indication to the vendor controls.
      a. Interface signals between the vendor controls and the District's existing control system will be hardwired.
      b. Interface signals will be monitoring only and routed to the existing RIO control panel as indicated on the drawings.
   2. Two new motorized actuated gates will be installed at the Chlorine Contact Basins.
      a. The gates are two-position (Open/Close)
      b. Open and Close controls will be available both locally at the gates as well as from the District's SCADA system.
      c. The control signals for each gate will be input to the District's existing RIO control panel as indicated on the drawings.
   3. Contractor is required to identify spare IO points of the type and quantities indicated on the drawings, in the control panel indicated.
      a. If sufficient spare IO points are not available, the Contractor will provide any additional I/O modules necessary.
      b. Contractor will be required to install any additional IO modules required and all associated wiring hardware including terminal blocks, circuit breakers, wiring, labels, etc. as necessary to allow new IO modules to function and to match existing installations.

C. **Operating facility:**
   1. As specified in Section 01140 - Work Restrictions.
   2. Portions of this existing facility must remain fully functional throughout the entire construction period. In consideration of this requirement, comply with the following guidelines:
      a. All outages must be of minimal duration and fully coordinated and agreed to by the District. Adjust the construction to meet the requirements of the District.
      b. As weather and facility demand conditions dictate, re-adjust the construction schedule to meet the demands placed upon District by its users.
      c. Where portions of the Work are in existing facilities and require interface to existing circuits, power systems, controls and equipment, perform comprehensive and detailed field investigations of existing conditions. Determine all information necessary to document, interface with, modify, upgrade, or replace existing circuits, power systems, controls, and equipment.
3. All controls and programming for demolished equipment not associated with new equipment shall be removed from the PLC and SCADA system.

1.05 SUBMITTALS

A. Furnish submittals as specified in this Section.

B. General:
1. Instruct all equipment suppliers of submittals and operation and maintenance manuals of the requirements in this Section.
2. Furnish the submittals required by each section in the Instrumentation Specifications.
3. Adhere to the wiring numbering scheme specified in Section 16075 - Identification for Electrical Systems throughout the Project:
   a. Uniquely number each wire.
   b. Wire numbers must appear on all Equipment Drawings.
4. Use equipment and instrument tags, as indicated on the Drawings, for all submittals.

C. Submittal organization:
1. First page:
   b. Name and telephone number of individual who reviewed submittal before delivery to Engineer.
   c. Name and telephone number of individual who is primarily responsible for the development of the submittal.
   d. Comments.
   e. Contractor’s review certification statement and signature.

2. Next pages:
   a. Provide confirmation of specification compliance:
      1) Specification section: Include with each submittal a copy of the relevant specification section.
         a) Indicate in the left margin, next to each pertinent paragraph, either compliance with a check (√) or deviation with a consecutive number (1, 2, 3).
         b) Provide a list of all numbered deviations with a clear explanation and reason for the deviation.
   b. Include a response in writing to each of the Engineer’s comments or questions for submittal packages which are re-submitted:
      1) In the order that the comments or questions were presented throughout the submittal.
      2) Referenced by index section and page number on which the comment appeared.
      3) Acceptable responses to Engineer’s comments are either:
         a) Engineer’s comment or change is accepted and appropriate changes are made.
b) Explain why comment is not accepted or requested change is not made.
c) Explain how requirement will be satisfied in lieu of comment or change requested by Engineer.

4) Any re-submittal, which does not contain responses to the Engineer’s previous comments shall be returned for Revision and Re-submittal.

5) No further review by the Engineer will be performed until a response for previous comments has been received.

3. Remaining pages:
   a. Actual submittal data:
      1) Organize submittals in exactly the same order as the items are referenced, listed, and/or organized in the specification section.
      2) For submittals that cover multiple devices used in different areas under the same specification section, the submittal for the individual devices must list the area where the device is intended to be used.

D. Submittal requirements:
   1. Furnish submittals that are fully indexed with a tabbed divider for every component.
   2. Sequentially number pages within the tabbed sections. Submittals and operation and maintenance manuals that are not fully indexed and tabbed with sequentially numbered pages, or are otherwise unacceptable, will be returned without review.
   3. Furnish submittals in the following general order, each in a separate bound set:
      a. Schedule of Values.
      b. Product Data.
      c. After Engineer acceptance of the Product Data, submit the Project Shop Drawing submittals.
      d. Loop Description Submittal.
      e. The Process Control Hardware and Software Submittal including, control system software, programming, and screens.
      g. Operation and Maintenance Data.
      h. Training Submittals.
      i. Record Documents.
   4. Edit all submittals and operation and maintenance manuals so that the submittal specifically applies to only the equipment furnished.
      a. Neatly cross out all extraneous text, options, models, etc. that do not apply to the equipment being furnished, so that the information remaining is only applicable to the equipment being furnished.
   5. Submit copies of shop drawings, and product data:
      a. Show dimensions, construction details, wiring diagrams, controls, manufacturers, catalog numbers, and all other pertinent details.
6. Where submittals are required, provide a separate submittal for each specification section. In order to expedite construction, the Contractor may make more than 1 submittal per specification section, but a single submittal may not cover more than 1 specification section:
   a. The only exception to this requirement is when 1 specification section covers the requirements for a component of equipment specified in another section. (For example, circuit breakers are a component of switchgear. The switchgear submittal must also contain data for the associated circuit breakers, even though they are covered in a different specification section.)

7. Exceptions to Specifications and Drawings:
   a. Include a list of proposed exceptions to the Specifications and Drawings along with a detailed explanation of each.
   b. If there is insufficient explanation for the exception or deviation, the submittal will be returned requiring revision and re-submittal.
   c. Acceptance of any exception is at the sole discretion of the Engineer.
      1) Provide all items (materials, features, functions, performance, etc.) required by the Contract Documents that are not accepted as exceptions.
   d. Replace all items that do not meet the requirements of the Contract Documents, which were not previously accepted as exceptions, even if the submittals contained information indicating the failure to meet the requirements.

E. Submittal preparation:
   1. During the period of preparation of submittals, the Contractor shall authorize direct, informal liaison between the ICSC and the Engineer for exchange of technical information. As a result of this liaison, certain minor refinements and revisions may be authorized informally by the Engineer, which do not alter the scope of Work or cause increase or decrease in the Contract price or times. During this informal exchange, no oral statement by the Engineer shall be construed to give formal approval of any component or method, nor shall any statement be construed to grant exception to, or variation from, these Contract Documents.
   2. In these Contract Documents, some items of Work are represented schematically, and are designated for the most part by numbers, as derived from criteria in ISA-5.1:
      a. Employ the nomenclature and numbers designated in this Section and indicated on the Drawings exclusively throughout shop drawings, data sheets, and similar submittals.
      b. Replace any other symbols, designations, and nomenclature unique to a manufacturer’s, suppliers, or subcontractor’s standard methods with those identified in this Section and indicated on the Drawings.

F. Specific submittal requirements:
1. Shop drawings:
   a. Required for materials and equipment listed in this and other sections.
   b. Furnish sufficient information to evaluate the suitability of the proposed material or equipment for the intended use, and for compliance with these Specifications.
   c. Shop drawings requirements:
      1) Front, side, and, rear elevations, and top and bottom views, showing all dimensions.
      2) Locations of conduit entrances and access plates.
      3) Component layout and identification.
      4) Schematic and wiring diagrams with wire numbers and terminal identification.
      5) Connection diagrams, terminal diagrams, internal wiring diagrams, conductor size, etc.
      6) Anchoring method and leveling criteria, including manufacturer’s recommendations for the Project site seismic criteria.
      7) Weight.
      8) Finish.
      9) Nameplates:
         a) As specified in Section 16075 - Identification for Electrical Systems or as indicated on the Drawings.
      10) Temperature limitations, as applicable.
   d. Use equipment and instrument tags as depicted on the P&IDs for all submittals.
   e. Adhere to wiring numbering scheme outlined in Section 16075 - Identification for Electrical Systems throughout the Project:
      1) Uniquely number each wire per the Specifications.
   f. Wire numbers must appear on all equipment drawings.
   g. Organize the shop drawing submittals for inclusion in the Operation and Maintenance Manuals:
      1) Furnish the initial shop drawing submittal bound in one or more standard size, 3-ring, D-ring, loose-leaf, vinyl plastic, hard-cover binders suitable for bookshelf storage.
      2) Binder ring size: 2 inches.
   h. Include the letterhead and/or title block of the firm responsible for the preparation of all shop drawings. Include the following information in the title block, as a minimum:
      1) The firm’s registered business name.
      2) Firm’s physical address, email address, and phone number.
      3) District’s name.
      4) Project name and location.
      5) Drawing name.
      6) Revision level.
      7) Personnel responsible for the content of the drawing.
      8) Date.
i. The work includes modifications to existing circuits:
   1) Clearly show all modifications to existing circuits.
   2) In addition, show all existing unmodified wiring to clearly depict the
      functionality and electrical characteristics of the complete modified
      circuits.

2. Product data:
   a. Submitted for non-custom manufactured material listed in this and other
      sections and shown on shop drawings.
   b. Include:
      1) Catalog cuts.
      2) Bulletins.
      3) Brochures.
      4) Quality photocopies of applicable pages from these documents.
      5) Identify on the data sheets the Project name, applicable specification
         section, and paragraph.
      6) Identify model number and options for the actual equipment being
         furnished.
      7) Neatly cross out options that do not apply or equipment not
         intended to be supplied.
   c. Use equipment and instrument tags as depicted on the P&IDs for all
      submittals.
   d. Adhere to wiring numbering scheme outlined in Section 16075 -
      Identification for Electrical Systems throughout the Project:
      1) Uniquely number each wire per the Specifications.
   e. Wire numbers must appear on all equipment drawings.

3. Detailed sequence of operation for all equipment or systems.

4. Operation and maintenance manuals:
   a. Submit preliminary sets of these manuals to the Engineer for review of
      format and content:
      1) Engineer will return 1 set with comments.
      2) Revise and/or amend as required and submit the requisite number
         of copies to the Engineer 15 days before Functional Testing of the
         systems.
   b. Incorporate changes that occur during process start-up and submit as
      part of the final manuals.
   c. Provide comprehensive information on all systems and components to
      enable operation, service, maintenance, and repair.
   d. Include Record Documents and the accepted shop drawing submittals,
      modified for conditions encountered in the field during the work.
   e. Include signed results from Functional Testing and Process Operational
      Period.
   f. Provide installation, connection, operating, calibration, setpoints (e.g.,
      pressure, pump control, time delays, etc.), adjustment, test,
      troubleshooting, maintenance, and overhaul instructions in complete
      detail.
g. Provide exploded or other detailed views of all instruments, assemblies, and accessory components together with complete parts lists and ordering instructions.

h. Spare parts list:
   1) Include a priced list of recommended spare parts for all the equipment furnished under this Contract:
      a) Include recommended quantities sufficient to maintain the furnished system for a period of 5 years.
   2) Annotate the list to indicate which items, if any and quantity are furnished as part of this Contract.

i. Provide the name, address, and phone number of manufacturer and manufacturer's local service representative of these parts.

j. Operational Manual:
   1) For Vendor Package Systems, provide the standard manufacturer's HMI software and system operations manual that includes all necessary instructions in the application of the system as required for operators in day-to-day operations.
      a) Submit a complete description of the standard application software programs, operating system and utility programs, including modifications and explanation of how the specific functional requirements are met:
      b) Provide a cross-reference between the Specification requirements and the software submittal, in order to provide the Engineer the ability to identify how each specified requirement or function is met.

k. Control System Software Record Documents:
   1) Include complete documentation of the software programs modified for this project, including:
      a) Listings of all application software on both hard copy and DVD, DVD-ROM, and CD-ROM.
      b) Database, both hard copy and DVD, DVD-ROM, and CD-ROM.
      c) Communication protocols where applicable.
      d) All documentation necessary to maintain, troubleshoot, modify, or update the software system.

l. Organize the operation and maintenance manuals for each process in the following manner:
   1) Section A - Process and Instrumentation Diagrams.
   2) Section B - Control Descriptions.
   3) Section C - Loop Drawings.
   4) Section D - Instrument Summary.
   5) Section E - Instrument Data Sheets and Brochures.
   6) Section F - Sizing Calculations.
   7) Section G - Instrumentation Installation Details.
   8) Section H - Test Results.
   9) Section I - Operational Manual.
10) Section J - Spare Parts List.
11) Section K - Control System Software.

5. Material and equipment schedules:
   a. Furnish a complete schedule and/or matrix of all materials, equipment, apparatus, and luminaries that are proposed for use:
      1) Include sizes, names of manufacturers, catalog numbers, and such other information required to identify the items.

6. Itemized instrument summary:
   a. Submit a hard copy of the instrument summary.
   b. List all of the key attributes of each instrument including:
      1) Tag number.
      2) Manufacturer.
      3) Model number.
      4) Service.
      5) Area location.
      6) Calibrated range.
      7) Loop drawing number.
   c. Associated LCP, VCP, PCM, or PLC.

7. Instrument data sheets and cut sheets:
   a. Furnish fully completed data sheets, both electronically in Microsoft Word or Excel and in hard copy, for each instrument and component according to ISA-20 Specification Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves. The data sheets provided with the instrument specifications are preliminary and are not complete. They are provided to assist with the completion of final instrument data sheets. Additional data sheets may be required. Include the following information on the data sheet:
      1) Component functional description specified in this Section and indicated on the Drawings.
      2) Manufacturers model number or other product designation.
      3) Tag number specified in this Section and indicated on the Drawings.
      4) System or loop of which the component is a part.
      5) Location or assembly at which the component is to be installed.
      6) Input and output characteristics.
      7) Scale range with units and multiplier.
      8) Requirements for electric supply.
      9) Requirements for air supply.
     10) Power consumption.
     11) Response timing.
     12) Materials of construction and of component parts that are in contact with, or otherwise exposed to, process media, and or corrosive ambient air.
     13) Special requirements or features, such as specifications for ambient operating conditions.
     14) Features and options that are furnished.
b. Provide a technical brochure or bulletin ("cut sheet") for each instrument on the project. Submit with the corresponding data sheets:
   1) Where the same make and model of instrument is used in 2 or more applications on the project, and the process applications are nearly identical, and the materials, features and options are identical submit one brochure or bulletin for the set of identical instruments.
   2) Include a list of tag numbers for which it applies with each brochure or bulletin.
   3) Furnish technical product brochures that are complete enough to verify conformance with all Contract Document requirements, and to reflect only those features supplied with the device.
   4) Cross out models, features, options, or accessories that are not being provided.
   5) Clearly mark and identify special options and features.

c. Organization: Index the data sheets and brochures in the submittal by systems or loops.

8. Control panel hardware submittal:
   a. Submit the following in 1 submittal package.
   b. Complete and detailed bills of materials:
      1) Including quantity, description, manufacturer, and part number for each assembly or component for each control panel.
      2) Include all items within an enclosure.
   c. Complete grounding requirements for each system component including any requirements for PLCs, process LANs, and Control System equipment.
   d. Requirements for physical separation between control system components and 120 VAC, 480 VAC, and medium voltage power cables.
   e. UPS and battery load calculations to show that the backup capacity and time meet the specified requirements.
   f. Provide a data sheet for each control system component together with a technical product brochure or bulletin, which include:
      1) The manufacturer's model number or other identifying product designation.
      2) Tag and loop number.
      3) System to which it belongs.
      4) Site to which it applies.
      5) Input and output characteristics.
      6) Requirements for electric power.
      7) Device ambient operating requirements.
      8) Materials of construction.

9. Schedule of values:
   a. In addition to completing all items referred to in the schedule of values, Section E01292 - Schedule of Values, submit per unit instrument and labor costs used in developing the final bid for the PCS system, for the express purpose of pricing and cost justification for any proposed change orders. It is the responsibility of the ICSC subcontractor to prove to the
Engineer’s satisfaction that said per unit costs were used in the development of the final Bid amount.

10. Installation recommendations:
   a. Submit the manufacturer’s printed recommendations for installation of instrumentation equipment.

11. Training submittals:
   a. Develop and submit for review a general training plan for approval by District within 14 calendar days from Notice to Proceed. Include complete descriptions of all planned training classes, a preliminary training schedule, a list of all proposed instructors along with resumes, examples of proposed training manuals, and a description of any special training tools to be used (simulators, self-paced modules, personal computer-based training, etc.).
   b. The Engineer will review the general training plan. Special emphasis will be placed on review of the qualifications of the proposed instructors and the timing of the individual courses to maximize their effectiveness. If, in the opinion of the Engineer, the proposed instructors are not sufficiently qualified to conduct the specified training courses, or lack experience, where required, on the specific configuration of the system, provide more qualified instructors.
   c. The general training plan and schedule shall be updated by the Contractor at the beginning of each Phase and approved by the District a minimum of 30 days prior to commencement of training.
   d. Training course plan submittals:
      1) For each training course or other training activity, submit a detailed, complete outline and agenda for each lesson as specified in Section 01756 - Commissioning.
      2) Describe any student pre-requisites for the course or training activity.
      3) Provide an updated schedule for all sessions of the course, including dates, times, durations, and locations.
      4) Submit training materials.
   e. Incorporate all submittal review comments into the course.
   f. Do not conduct training courses before review and acceptance of the Course Plan submittal for the course.

12. Project Record documents:
   a. Furnish as specified in Section 01770 - Closeout Procedures.
   b. Record Drawing requirements:
      1) Provide Project Record Drawing of all Instrumentation Drawings.
      2) Update Record Drawings weekly.
      3) Record Drawings must be fully updated as a condition of the monthly progress payments.
      4) Clearly and neatly show all changes including the following:
         a) All existing pipe, conduit, wire, instruments or other structures encountered or uncovered during construction.
c. Review and corrections:
   1) Correct any record documents or other documents found to be incomplete, not accurate, of poor quality, or containing errors.
   2) Promptly correct and re-submit record documents returned for correction.

13. Loop Drawings:
   a. Submit loop drawings for every analog, discrete, and fieldbus signal and control circuit:
      1) Provide a loop drawing submittal that completely defines and documents the contents of each monitoring, alarming, interlock, and control loop on this Project.
      2) This requirement applies to all signal and control circuits associated with equipment on this Project including vendor supplied equipment packages and control panels.
      3) Provide loop drawings in the format indicated in the contract drawings. Provide all tagging in accordance with the District’s standard.

   b. Show every instrument and I/O point on at least one loop diagram.

   c. Provide a complete index in the front of each bound volume:
      1) Index the loop drawings by systems or process areas.

   d. Provide drawings showing definitive diagrams for every instrumentation loop system:
      1) Show and identify each component of each loop or system using requirements and symbols from ISA-5.4.
      2) Furnish a separate drawing sheet for each system or loop diagram.

   e. In addition to the ISA-5.4 requirements, show the following details:
      1) Functional name of each loop.
      2) Reference name, drawing, and loop diagram numbers for any signal continuing off the loop diagram sheet.
      3) Show all terminal numbers, regardless of the entity providing the equipment.
      4) MCC panel, circuit, and breaker numbers for all power feeds to the loops and instrumentation.
      5) Designation of and, if appropriate, terminal assignments associated with, every manhole, pull-box, junction box, conduit, and panel through which the loop circuits pass.
      6) Show vendor control panel, instrument panel, conduit, junction box, equipment and PCS terminations, termination identification, wire numbers and colors, power circuits, and ground identifications.
      7) If a circuit is continued on another drawing, show the name and number of the continuation drawing on the loop drawing. Provide complete references to all continuation drawings whether vendor control panels, other loop drawings, existing drawings provided by the District, or other drawings.
f. In addition to the above requirements, provide loop diagrams in accordance with the example loop diagram as indicated on the Drawings.

14. **Instrument Installation Drawings:**
   a. Submit, instrument installation, mounting, and anchoring details for all components and assemblies, including access requirements and conduit connection or entry details.
   b. Furnish for each instrument a dedicated 8 1/2-inch by 11-inch installation detail that pertains to the specific instrument by tag number.
   c. For each detail, provide certification and the hard copies, by the instrument manufacturer, that the proposed installation is in accordance with the instrument manufacturer's recommendations and is fully warrantable.
   d. For each detail, provide, as a minimum, the following contents:
      1) Necessary sections and elevation views required to define instrument location by referencing tank, building or equipment names and numbers, and geographical qualities such as north, south, east, west, basement, first floor, etc.
      2) Ambient temperature and humidity where the instrument is to be installed.
      3) Corrosive qualities of the environment where the instrument is to be installed.
      4) Hazardous rating of the environment where the instrument is to be installed.
      5) Process line pipe or tank size, service and material.
      6) Process tap elevation and location.
      7) Upstream and downstream straight pipe lengths between instrument installation and pipe fittings and valves.
      8) Routing of tubing and identification of supports.
      9) Mounting brackets, stands, anchoring devices, and sun shades.
      10) Conduit entry size, number, location, and delineation between power and signal.
      11) NEMA ratings of enclosures and all components.
      12) Clearances required for instrument servicing.
      13) List itemizing all manufacturer makes, model numbers, quantities, lengths required, and materials of each item required to support the implementation of the detail.

15. **Control Panel Drawings:**
   a. **Layout Drawings:**
      1) Submit panel, enclosure, console, furniture, and cabinet layout drawings for all items provided.
      2) As a minimum, include the following information:
         a) To scale front, side, and plan views.
         b) Dimensions.
         c) Interior and exterior arrangements.
         d) Mounting information, including conduit entrance location.
e) Finish data.
f) Tag number and functional name of items mounted in and on each panel, console, and cabinet.
g) Nameplate legend including text, letter size, materials, and colors.

b. Wiring and piping diagrams:
   1) Submit panel wiring and piping diagrams for every panel that contains wiring and/or piping.
   2) Include the following information:
      a) Name of panel.
      b) Wiring and piping sizes and types.
      c) Terminal strip numbers.
      d) Wire tags and labels.
      e) Functional name and manufacturer's designation for items to which wiring and piping are connected.
      f) Electrical control schematics in accordance with ANSI standards.

c. Installation drawings:
   1) Provide site-specific installation drawings for all control equipment panels, including dimensions.
   2) Provide scaled drawings and show the position of the equipment at its intended installation location.
   3) Show the placement of all equipment being provided under this Contract and its spatial relationship to all other equipment located in the abutting and adjoining areas.
   4) Show all required access and clearances associated with the equipment with a statement of compliance to manufacturer's recommendations, NEC, and other applicable codes.

16. Schematic Diagrams:
   a. Submit schematic diagrams for all electrical equipment in ladder diagram format.
   b. Include device and field connection terminal numbers on all schematic diagrams.
   c. Incorporate equipment manufacturer’s shop drawing information into the schematic diagrams in order to document the entire control system.

17. Process Control Software Submittal:
   a. In accordance with Product Data and Shop Drawing general requirements.
   b. A complete listing of the PCS system point I/O database:
      1) Include for each data point, relevant parameters such as range, contact orientation, limits, incremental limits, I/O card byte, I/O hardware address, and PLC assignment.
      2) Organize on a site-by-site basis, separate by point type.
      3) In addition to the active I/O points, list the implemented spare I/O points and the available I/O points remaining on each card, as well as other defined future points specified or shown.
4) Upon completion of the Work, update all I/O lists to indicate the final as-built configuration of the systems:
   a) Organize as-built I/O list on a site-by-site basis, separated by equipment and point type.
   c. Detailed descriptions of procedures used to implement and modify control strategies and database construction.
   d. Preliminary overview, screens, station graphic displays, and preliminary reports.

18. Instrumentation and Control System Contractor Statement of Qualifications:
   a. Submit statement of qualifications of the proposed ICSC in accordance with subsequent requirements of this Section.

19. Control Descriptions:
   a. For each control loop, provide a detailed functional description of the operation of the equipment, signals, and controls as shown on the P&IDs:
      1) Include all functions depicted or described in the Contract Documents.
      2) Include within the Control Description content:
         a) All specific requirements.
         b) All common requirements that pertain in general to all loops.
         c) Listing all ranges, setpoints, timers, values, counter values, etc.

20. Test Procedure Submittals:
   a. Submit the proposed procedures to be followed during tests of the PCS and its components in 2 parts:
      1) Preliminary Submittal: Outline of the specific proposed tests and examples of proposed forms and checklists.
      2) Detailed Submittal: After successful review of the Preliminary Submittal, submit the proposed detailed test procedures, forms, and checklists. Include a statement of test objectives with the test procedures.

21. Test reports:
   a. Include the following:
      1) A description of the test.
      2) List of equipment used.
      3) Name of the person conducting the test.
      4) Date and time the test was conducted.
      5) All raw data collected.
      6) Calculated results.
      7) Each report signed by the person responsible for the test.

1.06 QUALITY ASSURANCE

A. Manufacture instruments at facilities certified to the quality standards of ISO 9001.

B. Furnish all equipment listed by and bearing the label of UL or of an independent testing laboratory acceptable to the Engineer and the Authority Having Jurisdiction.
C. All control panels must meet all UL 508/508A requirements.

D. ICSC:
   1. Contractor, through the use of a qualified ICSC, is responsible for the implementation of the PCIS including Vendor package systems.
   2. Due to the complexities associated with the interfacing of numerous control system devices, it is the intent of these Specifications that the ICSC be responsible for the installation and testing of the PCIS with existing devices as well as other devices provided under the Contract Documents with the objective of providing a completely integrated control system.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 01600 - Product Requirements.

B. Store all equipment and materials delivered to the job site in a location that will not interfere with the construction or the District’s operations.

C. Special instructions:
   1. Securely attach special instructions for proper field handling, storage, and installation to each piece of equipment before packaging and shipment.

D. Tagging:
   1. Tag each component and/or instrument to identify its location, instrument tag number, and function in the system.
   2. Firmly attach a permanent tag indelibly machine marked with the instrument tag number, as given in the tabulation, on each piece of equipment constituting the PCS.
   3. Tag instruments immediately upon receipt in the field.
   4. Prominently display identification on the outside of the package.
   5. Utilize the Tag and Loop Number identifications shown on the P&IDs.

E. Delivery and inspection:
   1. Deliver products in undamaged condition, in manufacturer’s original container or packaging with identifying labels intact and legible. Include date of manufacture on label.

1.08 PROJECT OR SITE CONDITIONS

A. Site conditions:
   1. Provide a PCS, including all equipment, raceways, and any other components required for a complete installation that meets the environmental conditions for the Site as specified in the General Requirements and below.
   2. Seismic classification:
      a. Provide all equipment and construction techniques suitable for the seismic requirements for the site, as specified in Section 01612 - Seismic Design Criteria.
3. Altitude, temperature and humidity:
   a. As specified in Section 01610 - Project Design Criteria.
   b. Provide all equipment and instrumentation fully rated for continuous operation at this altitude, temperature and humidity conditions with no additional derating factors applied.
   c. Provide additional temperature conditioning equipment to maintain all equipment and instrumentation in non-conditioned spaces or outdoors subject to these ambient temperatures 10 degrees Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit below maximum operating temperature as determined by the equipment manufacturer’s guidelines:
      1) Provide all power wiring for these devices (e.g., heaters, fans, etc.), whether or not indicated on the Drawings.

4. Area classifications:
   a. Furnish enclosures that match the area classifications as specified in Section 16050 - Common Work Results for Electrical.

5. Site security:
   a. Abide by all security and safety rules concerning the Work on the Site.

1.09 SEQUENCING

A. General:
   1. As specified in Sections 01312 - Project Meetings and 01756 - Commissioning.
   2. Testing requirements are specified in Sections 01756 - Commissioning, 17950 - Testing, Calibration, and Commissioning and other sections.
   3. General scheduling requirements are specified in Section E01310 - Project Control Schedule.
   4. Work restrictions and other scheduling requirements are specified in Section 01140 - Work Restrictions.
   5. Commissioning requirements as specified in Section 01756 - Commissioning.

B. Pre-submittal conferences:
   1. Before producing any submittals, schedule a pre-submittal conference for the purposes of reviewing the entire project, equipment, control philosophy, schedules, and submittal requirements.
   2. The Contractor, instrumentation and control subcontractor, electrical subcontractor, and all manufacturers furnishing major pieces of equipment must attend, including but not limited to:
      a. Vendor control panels.
      b. Chemical feed systems.
      c. Motor control centers.
      d. Switchgear.
      e. Variable frequency drives.
      f. Lighting.
      g. Engine generators.
C. System configuration meetings:
   1. Review the system configuration, the HMI system database, control schemes, displays, report formats, etc. with the Engineer and District on at least 3 occasions during development:
      a. Preliminary meeting: Before configuration work is begun. The ICSC must bring to this meeting example of displays, display symbols, reports, etc. to show the capabilities of the system software.
      b. Intermediate review meeting: Held after the initial database is entered and typical screens and reports have been entered.
      c. Presubmittal review meeting: Submit an informal hardcopy of developed HMI screens for review by the Engineer to determine that requirements are being sufficiently met.
      d. Final review meeting: Held after initial completion of all configuration work. This final meeting may not be held in conjunction with the Source Test. Make final format revisions after this review.
   2. Additional requirements as specified in Section 17100 - Control Strategies and Section 17101 - Specific Control Strategies.

D. Control logic meetings
   1. Review the PLC programming with the Programmer, Engineer, and District on at least 3 occasions during development. Individuals responsible for programming PLCs and other programmable devices supplied by Contractor shall attend this meeting by telephone conference call.
      a. Preliminary meeting: Meet before configuration work is begun on any PLCs programmed by the Contractor (including those provided through subcontractors and suppliers).
         1) Contractor shall provide a list of each PLC and other programmable devices that will interface to the rest of the control system, including make, model, and a description of the interface; provide contact information for each individual responsible for programming each said PLC and device; and provide a listing of the submittals that will contain HMI/LOI interface information with a schedule for when each submittal will be provided.
      b. Intermediate review meeting: Held after approximately one-half of the interface submittals identified in the Pre-submittal Conferences paragraph above have been submitted.
         1) Individuals responsible for programming PLCs and other programmable devices supplied by Contractor shall attend this meeting.
         2) Meet to discuss all control system interface submittals and their requirements.
      c. Final review meeting: Held after all HMI/LOI interface submittals have been submitted.
         1) Meet to discuss HMI/LOI interface submittals and requirements.
2. Vendor Equipment Meetings: Facilitate a meeting with each equipment supplier (including HVAC) who is providing equipment with a PLC and/or LOI. Meeting discussion point will include the following at a minimum:
   a. Tag Naming Conventions.
   b. PLC to PLC global data mapping.
   c. All PLCs to HMI tags mapping.
   d. LOI screen colors and navigation.
   e. Interlock and Permissive definitions.
   f. Communication Methods.
   g. Standard code blocks for common control functionality.
   h. Alarms: Clearing, formats, colors, and status.

E. General Field Start-Up and testing procedures:
   1. As specified in Section 01756 - Commissioning.

F. Installation testing:
   1. As specified in Section 01756 - Commissioning.
   2. Commence after acceptance of all training, wire test, calibration tests, and loop validation tests, and all inspections have demonstrated that the PCIS complies with all Contract requirements.
   3. Acceptance of the PCIS Installation testing must be provided in writing by the District before the performance testing may begin.

G. Training:
   1. As specified in Section 01756 - Commissioning.

H. Functional testing:
   1. Commence after acceptance of all training, wire test, calibration tests, and loop validation tests, and all inspections have demonstrated that the PCIS complies with all Contract requirements.
   2. Loop validation test.
   3. As specified in Section 17950 - Testing, Calibration, and Commissioning.
      a. Notify the District of scheduled tests a minimum of 21 days before the estimated completion date of installation and wiring of the PCIS.
      b. Complete loop validation testing a minimum of 5 days before the pre-commissioning phase of the project.
      c. Loop validation certifications:
         1) After the field device loop tests have been successfully completed as specified in Section 17950 - Testing, Calibration, and Commissioning for all individual instruments, all separate analog control networks, all valves, all VCPs, all motors, all local operator interface panels, all motor control centers, etc., submit a certified copy of all test forms signed by the Contractor, Vendor, and the District’s representative with test data entered, together with a clear and unequivocal statement that all instrumentation, including all control and signal wiring, has been successfully calibrated, inspected, and tested.
a) Acceptance of the PCIS Installation Testing must be provided in writing by the Engineer before the Process Operational Period may begin.

d. The Programmer will assist with Functional Testing for PLCs programmed by the Programmer, as specified in Section 17950 - Testing, Calibration, and Commissioning.

e. The Programmer shall not be required to be on site, nor shall the Programmer be required to supply application software, until the loop validation tests are complete for a PLC and all prerequisites for the Process Operational Period are completed.

I. Provide all special tools and spare parts, as specified in the Maintenance paragraph of this Section, before Process Operational Period commences, suitably wrapped, and identified.

J. Process Operational Period:
   1. Upon completion of the Process Operational Period, conduct an Instrumentation and Controls Process Performance Test as a condition for Project final completion.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. Provide additional warranty as specified in the individual Instrumentation and Control Specifications that extends beyond the Correction Period.

1.12 SYSTEM PROCESS START-UP

A. Replace or modify equipment, software, and materials that do not achieve design requirements after installation in order to attain compliance with the design requirements:
   1. Following replacement or modification, retest the system and perform additional testing to place the complete system in satisfactory operation and obtain compliance acceptance from the Engineer.

1.13 DISTRICT'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE

A. Before Substantial Completion, perform all maintenance activities required by the Contract Documents including any calibrations, final adjustments, component replacements or other routine service required before placing equipment or systems in service.

B. Furnish all spare parts as required by the Contract Documents.
C. Provide additional spare parts specified in other sections of the Instrumentation and Control Specifications.

D. Submit all special tools and spare parts, suitably wrapped and identified, before Process Operational Period commences.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Provide similar items from a single manufacturer throughout the PCIS portion of the Project.

B. Allowable manufacturers are specified in individual instrument and equipment specifications.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

A. Furnish all materials under this Contract that are new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these devices and that bear all approvals and labels as required by the Specifications.

B. Provide materials complying with the applicable industrial standard as specified in the Contract Documents.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS

A. Furnish all meters, instruments, and other components that are the most recent field proven models marketed by their manufacturers at the time of submittal of the shop drawings unless otherwise specified to match existing equipment.

B. Unless otherwise specified, furnish individual instruments that have a minimum accuracy of within 0.5 percent of full scale and a minimum repeatability of within 0.25 percent of full scale.

C. Signal transmission:
   1. Analog signals:
      a. Furnish analog measurements and control signals that vary in direct linear proportion to the measured variable, unless otherwise indicated.
b. Furnish electrical analog signals outside control panels that are 4 to 20 milliamperes 24 VDC, except as indicated.
c. Analog signals within enclosures may be 1 to 5 VDC.
d. Electrically or optically isolate all analog signals from other signals.
e. Furnish regulated analog signals that are not affected by changes in supply voltage or load resistance within the unit’s rating.
f. Maintain the total 4 to 20 milliamperes loop impedance to 10 percent below the published value at the loop operating voltage.
g. Where necessary, reduce loop impedance by providing current-to-current (I/I) isolation amplifiers for signal re-transmission.

2. Pneumatic signals:
   a. All pneumatic signals: 3 to 15 pounds per square inch gauge.

3. Discrete input signals:
   a. As indicated in the controller hardware specification.

4. Discrete output signals:
   a. Dry contacts or TRIAC outputs (with express written approval by the Engineer) as needed to coordinate with the field device.
   b. Provide external terminal block mounted fuse with blown fuse indication for all discrete outputs.
   c. Provide interposing relays for all discrete outputs for voltage and/or current compatibilities.
   d. Provide interposing relays as required for functionality of the control circuit.

5. Signal performance and design criteria:
   a. Stability:
      1) After Controls have taken corrective action, oscillation of the final control element shall not exceed 2 cycles per minute or a magnitude of motion of 0.5 percent of full travel.
   b. Response:
      1) Any change in setpoint or controlled variable shall produce a corrective change in position of the final control element and stabilized within 30 seconds.
   c. Agreement:
      1) Setpoint indication of controlled variable and measured indication of controlled variable shall agree within 3 percent of full scale over a 6:1 operating range.
   d. Repeatability:
      1) For any repeated magnitude of control signal, from either an increasing or decreasing direction, the final control element shall take a repeated position within 0.5 percent of full travel regardless of force required to position the final element.
   e. Sensitivity:
      1) Controls shall respond to a setpoint deviations and measured variable deviations within 1.0 percent of full scale.
   f. Performance:
1) All instruments and control devices shall perform in accordance with the manufacturers’ specifications.

D. Discrete circuit configuration:
   1. Configure discrete control circuits to fail safe, on loss of continuity or loss of power.
   2. Alarm contacts: Fail to the alarm condition.
   3. Control contacts fail to the inoperative condition unless otherwise indicated on the Drawings.

E. Grounding:
   1. Provide control panels with a signal ground bus, isolated from the power ground bus:
      a. Provide multiple panels in one location with a common point for signal ground bus connection to ground.
   2. Ground single-point ground shields and measurement loops at the source panel external terminals, unless otherwise noted, by bonding to the control panel signal ground bus.
   3. Provide isolating amplifiers within control panels for field equipment possessing a grounded input or output, except when the panel circuit is galvanically isolated.

F. Instrument air:
   1. Where indicated on the Drawings, provide dry, filtered control air at 30 pounds per square inch gauge nominal pressure piped to all field instruments and instrument panels requiring air:
      a. Provide each field instrument with an integral, non-adjustable filter/regulator assembly to provide regulated air.
      b. Provide each instrument panel requiring air with an adjustable filter/regulator assembly with gauge and an air manifold to provide air to pneumatic instruments.
      c. Filter all air to 5-micron maximum particle size.
      d. Provide low pressure switch to alarm on insufficient air supply.

2.07 ACCESSORIES

A. Provide flow conditioning devices or other required accessories if necessary to meet the accuracy requirements in the Contract Documents.

B. Nameplates:
   1. Provide a nameplate for each controller, instrument transducer, instrument power supply, solenoid, or any other control device located either in the field or within panels.
   2. All nameplates shall be of identical style, color, and material throughout the facility.
   3. Device nameplates shall include:
a. Designations as indicated on the Drawings and identified on the Process and Instrumentation Drawings.
   1) Device tag and loop number ID (e.g., FIT-60.011).
   2) PLC ID (e.g., PLC-11).
   3) Power information (e.g., PCM-11, 120VAC).
b. White lettering on a black background, laminated plastic.

4. All instruments shall be equipped with Type 316 stainless steel nameplate with the instrument tag stamped in 3/8-inch letters and connected to the instrument using Type 316 stainless steel wire.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

   A. Provide all equipment that is new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these products that bear all approvals and labels as required by the Specifications.

   B. Arrange with all manufacturers of the equipment and fabricators of panels and cabinets, to allow the District and Engineer to inspect and witness the testing of the equipment at the site of fabrication:
      1. Equipment includes the cabinets, special control systems, flow measuring devices, and other pertinent systems and devices.

   C. Source Test is specified in Section 17950 - Testing, Calibration, and Commissioning.

PART 3 EXECUTION

3.01 EXAMINATION

   A. The ICSC is encouraged to visit the site and examine the premises completely before bidding. It is the ICSC's responsibility to be fully familiar with the existing conditions and local requirements and regulations.

   B. Review the existing Site conditions and examine all shop drawings for the various items of equipment in order to determine exact routing and final terminations for all wiring and cables.

   C. Provide a complete instrumentation and control system:
      1. Install all extra conduits, cables, and interfaces as may be necessary to provide a complete and operating electrical, and process control and instrumentation system.
3.02  PREPARATION (NOT USED)

3.03  INSTALLATION

A. Equipment locations indicated on the Drawings may change due to variations in equipment size or minor changes made by others during construction:
   1. Verify all dimensions as indicated on the Drawings:
      a. Actual field conditions govern all final installed locations, distances, and levels.
   2. Review all information indicated on the Drawings, including architectural, structural, mechanical, instrumentation, and the accepted electrical, instrumentation, and mechanical shop drawings, and coordinate Work as necessary to adjust to all conditions that arise due to such changes.
   3. Make minor changes in location of equipment before rough in, as directed by the District or Engineer.

B. Perform all related Electrical Work in accordance with the applicable sections of the Electrical Specifications.

C. The PCIS configurations are diagrammatic:
   1. The locations of equipment are approximate unless dimensioned.
   2. Where Project conditions require, make reasonable changes in locations and arrangements.

D. Field instruments installation:
   1. Install field instruments as specified in the Contract Documents, API RP 550 and RP 551, and the manufacturer’s instructions.
   2. Mount field instruments so that they can be easily read, readily approached, and easily serviced, and so they do not restrict access to mechanical equipment:
      a. Mount field instruments on a pipe stand or local panel, if they are not directly mounted, unless otherwise indicated on the Drawings.
      b. Provide sun shields for all field electronic instruments exposed to direct sunlight.
   3. Make connections from rigid conduit systems to field instruments with PVC coated flexible conduit:
      a. Type of flexible conduit required for the area classification:
         1) Area classification as specified in Section 16050 - Common Work Results for Electrical.
      b. Maximum length of 18 inches.
   4. Connect field instruments with cable as specified in the Electrical Specifications, except when the manufacturer requires the use of special cable, or otherwise specified in this Section:
      a. Special cable applications shall be in accordance with the NEC.
   5. Verify the correctness of each installation:
      a. Polarity of electric power and signal connections.
6. Ensure all process connections are free of leaks.

E. Process sensing lines and air tubing:
   1. Install individual tubes parallel and/or perpendicular to and near the surfaces from which they are supported.
   2. Provide supports for rigid tubing at intervals of not more than 3 feet.
   3. Slope horizontal runs of instrument tubing at a minimum of 1/16-inch per foot to allow for draining of any condensate.
   4. Bends:
      a. Use proper tool.
      b. Make bends for parallel lines symmetrical.
      c. Make bends without deforming or thinning the walls of the tubing.
   5. Square-cut and clean all ends of tubing before being inserted in the fittings.
   6. Provide bulkhead fittings at all panels requiring pipe and/or tubing entries.
   7. Use stainless steel tubing for all piping hard piped from the air header, unless otherwise indicated on the Drawings or not compatible with the fluids or atmosphere in the area:
      a. Use flexible connections only on moving equipment and under the constraint that the length shall be less than 1.5 times maximum travel of the equipment.

F. Conduit, cables, and field wiring:
   1. Provide all PCS equipment cables, and process LAN communication networks under the Instrumentation and Control Specifications.
   2. Provide terminations and wire identification as specified in the Electrical Specifications.
   3. Protect all wiring from sharp edges and corners.
   4. Provide all conduits, fittings, boxes, etc. in accordance with all the requirements of the Electrical Specifications.

G. Equipment tie-downs:
   1. Anchor all instruments, control panels, and equipment by methods that comply with seismic and wind bracing requirements, which apply to the Site.
   2. All control panels, VCPs, LCPs, RTUs, PCMs, etc., shall be permanently mounted and tied down to structures.

H. Instrument tagging:
   1. As specified in Section 16075 - Identification for Electrical Systems.
   2. Provide all field-mounted instruments with nameplates:
      a. Nameplates engraved with the instrument’s full tag number as indicated on the Drawings:
         1) Affix tags with stainless steel wire fasteners.
   3. Provide all back of panel instruments with nameplates:
      a. Engraved with the instrument’s full tag number as indicated on the Drawings:
   4. Provide all front of panel instruments with a nameplate:
a. Engraving to include the following:
   1) Instrument’s full tag number.
   2) Service description.

b. Nameplates:
   1) Secure nameplates to the panel with stainless steel screws.
   2) Use an accepted adhesive if screws would violate the NEMA or other ratings of the enclosure.

I. Cable and conductor termination:
   1. Terminate all cables and conductors on terminal blocks.
   2. Terminal block enclosures:
      a. Suitable for the area classification as specified in Section 16050 - Common Work Results for Electrical.

J. Surge protection:
   1. Provide outdoor field instrument loops with voltage surge protection units installed on the instruments and the panel.
   2. Individually fuse each 4 to 20 milliamperes direct current loop with a 1/16 ampere fuse between power supplies and receiver surge protectors.
   3. Provide voltage surge protection for 4 wire transmitters and analyzers:
      a. Protect both power source and signal loop.

K. Scope and responsibilities:
   1. Refer to the following table for procurement and installation scope and responsibilities for the District, design engineer, contractor, integrator, and programmer.

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<tr>
<th>Item No.</th>
<th>Task</th>
<th>Responsible Parties</th>
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<td>District furnished equipment procurement.</td>
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<td>Equipment and package system procurement.</td>
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<td>District (D)</td>
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<tr>
<td>1.05</td>
<td>Update I&amp;C design to incorporate any changes, if changes approved by District during the submittal processes, for equipment and/or package systems.</td>
<td>A</td>
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<tr>
<td>2.00</td>
<td>HMI Application Programming</td>
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<tr>
<td>2.01</td>
<td>HMI software application programming.</td>
<td>A</td>
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<tr>
<td>2.02</td>
<td>Develop PLC/DCS interfaces to Vendor package systems (Vendor package system programmed by Vendor).</td>
<td>A</td>
</tr>
<tr>
<td>2.03</td>
<td>Digital field network interface and network configuration (ownership including calibration and setup).</td>
<td>A</td>
</tr>
<tr>
<td>2.04</td>
<td>HMI Graphical User Interface.</td>
<td>A</td>
</tr>
<tr>
<td>3.00</td>
<td>Vendor Package and Auxiliary System Application Programming</td>
<td></td>
</tr>
<tr>
<td>3.01</td>
<td>Vendor Package PLC software application programming (procured by Contractor).</td>
<td>A</td>
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<tr>
<td>3.02</td>
<td>Configuration of auxiliary systems necessary to provide required functionality and connectivity for monitoring and control of auxiliary systems: HVAC, Power Monitors, Lighting, and Fire Protection.</td>
<td>A</td>
</tr>
<tr>
<td>4.00</td>
<td>Integration</td>
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<tr>
<td>4.01</td>
<td>Instrumentation specifications and procurement.</td>
<td>A</td>
</tr>
<tr>
<td>4.02</td>
<td>Vendor supplied package and Auxiliary system coordination with plant PLC/DCS (communications, submittals, software development).</td>
<td>A</td>
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<tr>
<td>4.03</td>
<td>Vendor package systems and Auxiliary system interface demonstration at FAT, where required.</td>
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<td>Item No.</td>
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<td>Responsible Parties</td>
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<td>District (D)</td>
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<td>Design Engineer (DE)</td>
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<td>Integrator (I)</td>
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<td>Programmer (P)</td>
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<td></td>
<td></td>
<td>Service or Equipment Supplied By</td>
</tr>
<tr>
<td>4.04</td>
<td>Control system equipment, Vendor package system, and Auxiliary system interface submittal review and preparation for formal District review.</td>
<td>S</td>
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<tr>
<td>4.05</td>
<td>I&amp;C Design update to reflect approved vendor submittals (if required).</td>
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<td>5.00</td>
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<td>5.01</td>
<td><strong>PLC/DCS Process Control System</strong></td>
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<td>5.02</td>
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<td>5.03</td>
<td>PLC/DCS panels and associated panel equipment fabrication.</td>
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<td>5.04</td>
<td>PLC/DCS panels factory testing.</td>
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<td>5.05</td>
<td>PLC/DCS installation.</td>
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<td>5.06</td>
<td>PLC/DCS field testing OAT, SAT.</td>
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<td>5.07</td>
<td>Operator Interface Stations (both in panel and desktop) related setup and configuration.</td>
<td>W</td>
</tr>
<tr>
<td>5.08</td>
<td>Field PLC/DCS interfaces (HMIs).</td>
<td>A</td>
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<tr>
<td>5.09</td>
<td><strong>Communications</strong></td>
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<td>5.10</td>
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<td>5.11</td>
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<td>5.12</td>
<td>Copper patch panel procurement and installation.</td>
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<td>5.13</td>
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<td>5.14</td>
<td><strong>Field Local Control Panels (LCPs)</strong></td>
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<td><strong>Local Operator Interfaces (LOIs)</strong></td>
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<td>5.18</td>
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<td>6.02</td>
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<td>6.04</td>
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<td>7.00</td>
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<td>7.01</td>
<td>Building electrical provision and installation - cable / conduit / wire.</td>
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<td>7.02</td>
<td>Building mechanical provision and install - including process instruments related tubing</td>
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<tr>
<td>7.03</td>
<td>Building wiring racks and supports (cable and/or conduit) - coordinated w/DIV 16 power contractor where applicable.</td>
<td>L</td>
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<td>7.04</td>
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<td>7.05</td>
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<td>7.06</td>
<td>Electrical and mechanical installation inspection.</td>
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<td>7.07</td>
<td>Vendor Package - On/Off Skid related electrical controls installation.</td>
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<td>Vendor Package - On/Off Skid related mechanical controls installation.</td>
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<td>Site Fiber Optic backbone cable installation, termination, and certification testing.</td>
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<td>9.01</td>
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<td>A L I</td>
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<tr>
<td>9.02</td>
<td>As-builts (record set) - Update All Drawings.</td>
<td>A L I</td>
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<tr>
<td>9.03</td>
<td>Operation and Maintenance Manuals.</td>
<td>A L I</td>
</tr>
<tr>
<td>9.05</td>
<td>Training.</td>
<td>W A L S I</td>
</tr>
<tr>
<td>9.06</td>
<td>Commissioning (process performance testing).</td>
<td>L A A A S D</td>
</tr>
</tbody>
</table>

Key: L – Lead, A – Assist, S – Support, W – Witness
3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. District Training:
   1. Demonstration requirements are specified in Section 17950 - Testing, Calibration, and Commissioning.

<table>
<thead>
<tr>
<th>Course Title</th>
<th>Minimum Course Length (hours per session)</th>
<th>Personnel (Estimated Number of Students)</th>
<th>Minimum Number of Sessions</th>
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</thead>
<tbody>
<tr>
<td>System Overview</td>
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<td>10</td>
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<tr>
<td>Operator Training - Basic</td>
<td>4</td>
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<td>Operator Training - Advanced</td>
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<td>2</td>
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<tr>
<td>LOI Hardware and Software</td>
<td>4</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>

2. Training course requirements:
   a. System overview training:
      1) Furnish a training course that gives the District’s supervisory level personnel an overview of the new Contractor-provided elements of the PCIS system. Focus on the overall functional aspects of each new elements of the control system, particularly the mechanical system vendor-provided control packages.
   b. Operator training:
      1) Furnish training courses that instruct system operators in the efficient operation of Contractor-provided aspects of the PCIS that include not only the general operation of each control system but also the operation of specific system features.
      2) Operator’s training shall include the following for each vendor package and programmable device:
         a) Control system overview: Architecture, equipment functions, software components, etc.
         b) Display navigation, overview, and types of displays.
         c) Process and equipment monitoring and control: Basic principles and operation.
d) Logging ON and OFF the system and description of the security and access system.
e) Alarm subsystem.
f) Trending: Provide a thorough session on how to use all trending functions.
g) Reports: How to access, print, and review content.
h) Control strategies: Present an average 15-minute review of each control strategy, including a hands-on demonstration of screens and operator functions for each.
i) Instruction on the use of all operational functionality alarm logging, trending, displays, database, reports, and control software developed for the Project and incorporated in the installed PCIS system.

c. LOI hardware and software training:
   1) Provide the following:
      a) Overview of hardware and firmware, including starting, stopping, and PLC interface.
      b) Configuration of tag database.
      c) Creating, editing, and saving display screens.
      d) Troubleshooting.

3.08 FIELD QUALITY CONTROL

A. Inspection:
   1. Allow for inspection of PCIS installation as specified in Section 01450 - Quality Control.
   2. Provide any assistance necessary to support inspection activities.
   3. Engineer inspections may include, but are not limited to, the following:
      a. Inspect equipment and materials for physical damage.
      b. Inspect installation for compliance with Drawings and Specifications.
      c. Inspect installation for obstructions and adequate clearances around equipment.
      d. Inspect equipment installation for proper leveling, alignment, anchorage, and assembly.
      e. Inspect equipment nameplate data to verify compliance with design requirements.
      f. Inspect cable terminations.
      g. Inspect/witness instrument calibrations/verifications.
   4. Inspection activities conducted during construction do not satisfy inspection requirements specified in Section 17950 - Testing, Calibration, and Commissioning.

B. Instrument Installation Inspection:
   1. Provide any assistance necessary to support inspection activities.
   2. Inspections may include, but are not limited to, the following:
      a. Inspect equipment and materials for physical damage.
b. Inspect the installed arrangement, lay lengths, orientation, piping obstructions, etc., that could affect the instruments accuracy or repeatability.
c. Inspect installation for compliance with Drawings and Specifications.
d. Inspect installation for obstructions and adequate clearances around equipment.
e. Inspect equipment installation for proper leveling, alignment, anchorage, and assembly.
f. Inspect equipment nameplate data to verify compliance with design requirements.
g. Inspect cable terminations.
h. Inspect/witness instrument calibrations/verifications.

3. Inspection activities conducted during construction do not satisfy inspection requirements specified in Section 17950 - Testing, Calibration, and Commissioning.

4. Field acceptance testing: (Functional Testing) is specified in Section 17950 - Testing, Calibration, and Commissioning. Additional general requirements are specified in Section 01756 - Commissioning.

C. Installation supervision:
   1. Ensure that the entire PCIS is installed in a proper and satisfactory manner. At a minimum, the ICSC shall provide the following services:
      a. Installation resources:
         1) Coordinate with the Contractor regarding installation requirements of the Contract Documents.
      b. Provide technical assistance to installation personnel by telephone:
         1) Furnish installation personnel with at least 1 copy of the accepted submittals, including all installation details.
      c. Periodic inspections during the construction period.
      d. A complete check of the completed installation to ensure that it is in conformance with the requirements of the equipment manufacturer and the Contract Documents.
      e. Field verify accuracy and calibration of all instruments.

3.09 ADJUSTING

A. Control valves and motorized Gates:
   1. Stroke all control valves and motorized gates, cylinders, drives and connecting linkages from the control system as well as local control devices and adjust to verify proper control action, hand switch action, limit switch settings, torque settings, remote control actions, and remote feedback of valve status and position.
   2. Check control valve and motorized gate actions and positioner settings with the equipment in place to ensure that no changes have occurred since the bench calibration.
B. Make all revisions necessary to the control system software, as directed by the Engineer.
   1. It is understood that the Contractor knows and agrees that changes will be required in the control system software during the Source Testing, Functional Testing, Process Operational Period, Process Start-Up, and during the Project Correction Period.

3.10 CLEANING

A. As specified in Section 01770 - Closeout Procedures.

B. Vacuum clean all control panels and enclosures before process start-up and again after final completion of the project.

C. Clean all panel surfaces.

D. Return to new condition any scratches and/or defects.

E. Wipe all instrument faces and enclosures clean.

F. Leave wiring in panels, manholes, boxes, and other locations in a neat, clean, and organized manner:
   1. Neatly coil and label all spare wiring lengths.
   2. Shorten, re-terminate, and re-label excessive spare wire and cable lengths, as determined by the Engineer.

G. As specified in other sections of the Contract Documents.

3.11 PROTECTION

A. Protect all Work from damage or degradation until date of Substantial Completion.

3.12 SCHEDULES (NOT USED)

END OF SECTION
SECTION 17100
CONTROL STRATEGIES

PART 1   GENERAL

1.01 SUMMARY

A. Section includes:
   1. Contractor-developed loop description submittal requirements.
   2. General programming requirements.
   3. Common control functions:
      a. General control and monitoring functions to be provided throughout the
         PCS system.
         1) These requirements apply to all systems, and supplement the
            specific loop descriptions in Section 17101 - Specific Control
            Strategies and information indicated on the Drawings.

1.02 REFERENCES

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

1.03 DEFINITIONS

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

B. Hardwired control: Control circuitry that does not utilize software to initiate
   functionality.

C. Hardwired interlocks: A safety or protective feature that will interrupt operation of
   the equipment in all operating modes with no required operator intervention.

D. Software interlocks: A safety or protective feature that will interrupt operation of
   the equipment when the PLC has control.

E. Slew rate: Rate of change in respect to time.

F. Clamp: Imposed upper and lower limits on setpoints to eliminate entries outside
   the allowable control parameters.

G. Watchdog timer: Timers imposed to test components such as discrete I/O to verify
   the health of the card.

1.04 SYSTEM DESCRIPTION (NOT USED)
1.05 SUBMITTALS

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

1.06 QUALITY ASSURANCE (NOT USED)

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

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

1.12 SYSTEM START-UP (NOT USED)

1.13 DISTRICT’S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS (NOT USED)

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)
2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION (NOT USED)

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION

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

B. General programming requirements:
   1. Use variable names or aliases derived from tag and loop identification on the P&IDs for all process values.
      a. Submit names for District approval.
      b. Unless otherwise noted, utilize floating-point format for all PLC algorithms and calculations.
      c. Provide PLC logic to convert raw input values into engineering units in a floating-point format.
   2. Store all adjustable parameters in the PLC, and configure so that an operator with sufficient security access can change the parameters from the LOI or HMI. Update and display the current value at all locations, regardless of where the last change was made.
   3. Documentation:
      a. All control logic shall be completely annotated including all rungs, instructions, and tags.
      b. Each routine shall have a title and a detailed description of the control strategy represented by the control logic. Where parameters are passed to the routine, all parameters shall be defined in the routine description.
      c. Analog tag descriptions representing process variables shall include the engineering unit range of the analog variable.
      d. Digital tag descriptions shall include the On and Off state labels.
      e. Complete, grammatically correct sentences and terminology, consistent with water treatment processes, shall be utilized in the development of rung and routine descriptions.
      f. All equations developed in the process logic shall be fully documented in the rung or routine description. A description of each constant and variable utilized in the equation shall be defined including engineering units.
4. Program slew rates for setpoints as needed to limit the effect of updated setpoints on the process:
   a. Provide for control setpoints and manual speed and position selections.
   b. Store new setpoints in one register, and gradually ramp the actual setpoint register at the slew rate until it reaches the new value.
   c. Provide operator access to change slew rates from the HMI.
5. Saved setpoints:
   a. Provide an operator selection to save all setpoint values.
   b. Where possible, provide an operator selection to restore all setpoints to the initial start-up value.
   c. Provide an operator selection to restore all setpoints to the last saved value.
6. Store a copy of all adjustable parameters and accumulated and integrated totals in PCS:
   a. Upon re-loading of the PLC program, re-load these values to the PLC from PCS or processor memory card.
   b. PLCs provide a minimum 2 week data storage to provide for data accumulation and later communication to the Historian in the event of a network interruption.
7. Calculated values:
   a. Program calculations such that division by zero errors cannot occur.
   b. Prevent calculations from generating values that exceed the limits of the equipment or data type structures (integers) internal to the PLC.
   c. Configure counting functions (start counts and operation counts) to allow a minimum of 10,000 counts, and to roll-over to zero at an even decimal interval (1 followed by 4 or more zeros).
   d. Configure integrating functions to accurately accumulate the maximum rate from the instrument/equipment (totalizers, run time meters) for 30 years. Utilize manufacturer AOI/DFBs etc. where possible.
8. Timers:
   a. Provide programmable settling and proving timers in control sequences as required for starting and stopping of equipment to allow the process to settle down before proceeding with any additional control functions.
      1) The settling timers may be overridden by setting the timer to 0 seconds.
9. Control Panel status:
   a. Design the PLC system to function as a stand-alone unit that performs all of the control functions described in this Section completely independent from the functions of the PCS system PC-based operator interfaces:
      1) Failure of the PCS system shall not impact data acquisition, control, scaling, alarm checking, or communication functions of the PLC.
   b. Furnish a minimum of 1 screen that depicts the status of all enclosures containing PLCs, communication equipment, UPS or I/O in the control system, including but not limited to the following:
      1) PLC cabinet over-temperatures from high temperature switch.
2) Intrusion status on all enclosures equipped with intrusion switches.
3) AC power failure:
   a) Monitor ahead of UPS.
4) DC power supply failure:
   a) For redundant power supplies, alarm when either power supply or the diode bridge fails.
5) UPS failure signal.
6) UPS Low Battery signal.
7) Digital bus network Coupler and or Gateway failure signal.
8) Ethernet Switch failure signal.

10. PLC system communication status:
    a. Furnish a minimum of 1 screen to display all communication errors and status within the PCS:
       1) Communication between PCS and PLCs, PLC to PLC, PLC to RIO and PLC and or PCS to VCP.
       2) 4-20 mA HART interface cards.
       3) Digital bus network status:
          a) Profibus scanners.
       4) Modbus Gateway modules.
       5) Display status of each node, and summary of failures over the past 60 minutes.
    b. Generate a communications alarm if any communication fault is detected or there is no response from a node for more than a user specified time.
    c. In the event of communications loss:
       1) Where control parameters are received over a communications link:
          a) If a link fails where process elements use the remote value for closed-loop control, hold operating status, speed and position, of the process elements at their last state before the communication alarm, unless other I/O local to that PLC indicates shutdown or over-ride conditions:
             (1) Ensure that the operator can control the process using PCI\S HAND mode at the local LOI.
          b) If a link fails where process elements use the remote value to determine setpoints, continue to operate using the last value received:
             (1) Provide a manual over-ride entry at the local LOI to allow an operator to enter a different value for any such remote signal.
             (2) Generate an alarm whenever an over-ride value is in use.

C. Common control functions:
   1. Incorporate common control functions into all control loops and devices and into the control programming, whether or not specifically shown in the specific control descriptions or elsewhere in the Contract Documents.
2. Alarms:
   a. Generate alarms within the PLC logic.
   b. Indicate alarms at the LOI and HMI. Enable acknowledgement from either
      the HMI or the LOI.
   c. Generate high, high-high, low, and low-low level alarms where indicated:
      1) Provide an alarm reset deadband for each analog value to prevent
         excessive repeated alarms.
      2) Provide logic and timers to inhibit analog alarms based on process
         events. For example, inhibit low flow alarms when a pump is
         stopped, or has not been running long enough to establish flow.
   d. Flash all alarm and fail conditions and their respective indicators on the
      PCS graphic screens and local indicating lights until the condition is
      acknowledged by the operator, even if the alarm condition is no longer
      present.
   e. Once the alarm is acknowledged by an operator, display alarm conditions
      in a steady state (not flashing) while the alarm condition is still present:
   f. Once the alarm has been cleared and the operator has acknowledged
      the alarm or fail condition, turn the graphic alarm indicator off.
   g. For all alarms that do not have inherent timers, provide an operator-
      adjustable proving timer to limit nuisance alarms, continuously adjustable
      from zero seconds to 100 minutes. The initial setting of proving timers
      shall be zero seconds:
      1) The PLC shall start the timer when it first detects an alarm condition,
         and shall only activate the alarm after the timer has expired.
      2) If the alarm condition clears while the timer is running, the timer
         shall reset, and the alarm shall not be activated.
   h. Use interlocks and proving timers to prevent alarms from operating due
      to power loss, except for loss of power alarms.
   i. Furnish an alarm silence pushbutton at each PCM, LOI, or LCP with an
      audible alarm to signal the PLC to turn off the audible alarm until the next
      alarm occurs.
   j. Lamp test: Furnish lamp test pushbuttons at each control panel with
      more than 10 pilot lights, that illuminates all pilot lights on the panel:
      1) The lamp test may sequence through blocks of lights.
      2) Minimum on time for each lamp during lamp test 15 seconds.
   k. Horns and Beacons:
      1) Activate PCM horn and beacon on all critical alarms and on other
         alarms as defined by the Facility Alarm Philosophy.
      2) Deactivate PCM horn and beacon when PCM reset pushbutton is
         activated.
      3) Silence PCM horn when PCM silence pushbutton is activated.
   l. Dual analog instruments:
      1) For applications where 2 or more analog instruments are measuring
         the same process variable:
         a) Generate an operator adjustable percent deviation alarm.
b) Allow operator to take each instrument out of service when an instrument is out of service.

3. Where a reset is shown for counts, totals and times maintained in the PLC:
   a. Provide a reset selection on the HMI screen that displays the value.
   b. Provide a preset function on the HMI to allow an operator-entered value to become the current accumulated total.
   c. Limit access to the reset and preset functions to operators with suitable security level.
   d. Log the value before reset, operator, time, and date of reset in the PCS archive.
   e. Log the value before preset, preset value, operator, time, and date of preset in the PCS archive.

4. Where start counts are indicated on the Drawings, or required in this Section, count starts for each piece of equipment (off to on transitions of running status) in the PLC:
   a. Display total starts on PCS screens, and provide a reset function.
   b. Where indicated, calculate number of starts for each day:
      1) Display current day and previous day starts on PCS displays.
      2) Do not reset daily start count when overall count is reset.
      3) Archive starts for each day through PCS.

5. Where run time accumulation is indicated on the Drawings, or required in this Section, integrate accumulated run time to the nearest 0.1 hour whenever the running status input indicates that the equipment is running:
   a. Display total run time in hours on PCS screens.
   b. Where indicated, calculate total run time for each day:
      1) Display current day and previous day run time on the HMI to the nearest 0.1 hour.
      2) Do not reset daily run time when overall time is reset.
      3) Archive run time for each day through PCS.

6. For all monitored analog values:
   a. Convert all values to engineering units in floating-point format within the PLC.
   b. Maintain trends in PCS.
   c. Flows and Weights:
      1) Totalize flows in the PLC logic:
      2) Where totalized flows are input to a discrete input, count input pulses and multiply by the volume per pulse.
      3) Where no totalizer input is shown, integrate the analog input over time.
      4) Display totals on the HMI and LOI.
      5) Archive totals to the historical database through PCS.
   d. Generate an alarm whenever an over-ride value is in use.
7. Analog data processing:
   a. Engineering units conversion:
      1) Use engineering units for all analog point values. Convert analog inputs to engineering units.
   b. Analog magnitude checking:
      1) Provide upper and lower limits to prevent operator-entered values (setpoints, etc.) from falling outside acceptable limits.

8. Tank and vessel levels:
   a. Display all tank and vessel levels in feet:
   b. Monitor rate of change of volume on all tanks and vessels:
      1) Establish the maximum withdraw rate at which the volume should decrease (all pumps or feeders operating at maximum output). Generate an alarm whenever the volume decreases faster than this rate.
      2) Establish the minimum fill rate at which the volume should increase when filling. Generate an alarm whenever the volume increases faster than this rate. Verify tank and vessel level is fluctuating to verify the validity of the IO register. If it is determined the register is not active or failed in a manner that leaves a stagnant value generate an alarm.

9. I/O filtering and processing:
   a. Analog input filtering:
      1) For each analog input provide an adjustable first order filter, for the purpose of smoothing out spikes and other noise for analog transmitter input signals. By default, configure analog inputs with no filtering affect.
      2) Monitor analog input signal quality:
         a) Over range: The input value is above the normal range (typically over 21 mA).
         b) Under range: The input value is below the normal range (typically under 3 mA, indicating a probable broken connection).
         c) Generate alarms for over or under range inputs.
         d) Do not use over or under range values for control or calculation purposes:
            (1) Where a second instrument is provided to monitor the same condition (a redundant instrument, or additional instruments furnished for averaging or different operating modes), and has a valid signal, use that input for control.
            (2) Else, hold all outputs affected by the signal at their last values before the signal went out of range.
      3) Digital input filtering (proving timer):
         a) Provide an adjustable time delay function (0-10 seconds) on discrete input for the purpose of de-bouncing.
         b) By default, discrete inputs shall be configured with de-bounce timers set to zero seconds.
10. Instrument scaling (HMI/LOI):
   a. Provide 1 or more maintenance screens to display ranges and trigger points for all field instruments:
      1) For analog instruments, use input scaling values in the PLC to determine minimum and maximum calibration points.

11. PCS HAND-OFF-AUTO:
   a. Where indicated, provide HAND-OFF-AUTO and START-STOP selections in the PCS, accessed from an LOI or HMI for operators with sufficient security, to provide the following operating modes:
      1) PCS AUTO: The normal, automatic control mode of the strategy which allows full PLC control in response to process conditions and programmed sequences.
      2) PCS HAND: Enables PCS Manual control where control decisions are made by an operator through the PCS START-STOP, OPEN/CLOSE, or other selections as indicated.
      3) PCS OFF: Automated PCS control is disabled and PLC calls for all associated equipment to stop and valves to close or go to their identified safe state.
      4) Program the PLC so that switching a strategy between AUTO and HAND (either direction) occurs with a smooth transition. Keep running or position status unchanged when control is switched to HAND until a change is requested using the operator selections (START, STOP, OPEN, CLOSE). Keep running and position status unchanged when control is switched to AUTO until the control logic determines a change is required.

12. Display the current status of all operator selections (PCS HAND/AUTO, PCS START/STOP, etc.) on LOI and HMI.

13. Interlocks:
   a. Implement software interlocks where indicated to place equipment in a safe condition in response to impending hazardous process conditions. Apply software interlocks when equipment is operating in PCS AUTO or PCS HAND:

14. Permissives:
   a. Implement software permissives where indicated to prevent equipment from starting in an unsafe condition.
   b. Apply software permissives when equipment is operating in PCS AUTO or PCS HAND.

15. Process control algorithms:
   a. Jog and hold: Unless otherwise indicated, use jog and hold control algorithms where possible:
      1) When the error between process variable and setpoint is beyond a setpoint deadband:
         a) Jog valve or ramp speed in the required direction for a preset “Jog Time” or until the process variable reaches or passes the setpoint.
b) Then hold speed or position through a setpoint “Hold Time.”
c) Continue alternating jog and hold until the error is less than the deadband.

2) Provide operator access to Jog Time and Hold Time setpoints from the HMI.

b. PID algorithms: Use where indicated, or where necessary to provide fast response:
   1) Provide a PID faceplate with the following displays and functions for each PID control algorithm:
      a) Display Output, CV.
      b) Display Setpoint, SP.
      c) Display Process Variable, PV.
      d) Allow for operator selection of Automatic or Manual control of the output.
      e) Under Manual control of output allow the operator to enter the desired output value.
      f) Allow for input of the 3 Proportional, Integral, and Derivative tuning parameters.
      g) Configure PID loops to prevent reset windup when controlled equipment is operating in Manual (local or PCS), or when the equipment has reached a physical limit.
      h) When controlled equipment is being operated in remote PCS HAND, configure the PID function to track the process variable to provide a smooth transfer between Manual and Automatic modes.
      i) Provide selectable slew rates with adjustable setpoints to allow the PID algorithm to slowly ramp to its final value to minimize system disturbance.

16. Equipment alternating and sequencing:
   a. Distribute number of starts and run time equally between identical equipment.

17. Motor control:
   a. Monitor the device’s LOCAL-OFF-REMOTE (LOR) switch (the hard-wired switch at the MCC, drive or equipment) to determine when the PLC has control of the associated equipment:
      1) Display current REMOTE status on the PCS screens.
   b. Monitor the device’s running status from the starter auxiliary or run status input:
      1) Display the current status (running or stopped) on the PCS screens.
      2) Use status to calculate total run time and daily run time, and to count total starts and daily starts.
      3) Provide time stamp for each start.
      4) For motors 200 HP and greater, provide software to prevent exceeding the manufacturer’s recommended maximum starts per hour.
c. When equipment control has been given to the PLC as reported by the LOCAL-OFF-REMOTE switch, allow selection of PCS AUTO or PCS HAND control modes based upon operator selection using the PCS screens.

d. Starting, stopping and running when the device LOR is in LOCAL:
   1) With the LOR switch in the LOCAL position, the motor is controlled by the START and STOP pushbuttons.
   2) With the LOR switch in the OFF position, the motor is prohibited from running.
   3) With the LOR switch in the REMOTE position, the motor is controlled remotely.

e. Starting, stopping and running when the device LOR is in REMOTE:
   1) When the motor is expected to be running (PLC has issued a START or RUN due to process conditions or operator selection), LOR is in REMOTE, and the device is not reported to be running, start an operator adjustable “Control Activation” timer:
      a) Provide “Control Activation” timers for each piece of controlled equipment:
         (1) If the LOR and required running status do not change, and the PLC does not receive running status within the “Control Activation” time period:
            (a) De-activate the output.
            (b) Place the device in a “Failed” state.
            (c) Generate a “Failed to Respond” alarm.
   2) When the motor is not expected to be running (PLC has issued a STOP or removed the RUN output), LOR is in REMOTE, and the device is reported to be running, start the “Control Activation” timer:
      a) If the LOR and required stopped status do not change, and the PLC does not lose the running status within the “Control Activation” time period:
         (1) Keep the RUN output off or the STOP output on.
         (2) Place the device in a “Failed” state.
         (3) Generate a “Failed to Respond” alarm.
   3) Re-establish PLC control of a device in a “Failed” state only after the following:
      a) An operator turns the device’s LOR switch out of REMOTE, and back to REMOTE (i.e., REMOTE input to the PLC cycles off and back on).

f. Where motor winding high temperature switches or RTD temperature elements are shown, generate an alarm when high temperature is sensed (contact opens or temperature above the high alarm setpoint), but do not stop the motor unless otherwise indicated.

g. Motor equipped with current detection shall shut down and report a “failed” status on detection of high current.

h. Control two-speed motors similar to other motors, except as listed below:
   1) Motor states are RUN-FAST, RUN-SLOW, and STOP.
2) Start all two-speed motors in the RUN-SLOW state. If or when the high speed is required (RUN-FAST operator selection or process conditions), transition to RUN-FAST after a designated time.

3) When transitioning from RUN-FAST to RUN-SLOW, remove the RUN-FAST output or issue a STOP, then wait for a “Fast to Slow” time delay before energizing the RUN-SLOW or START-SLOW output.

i. Simultaneous starts:
   1) Prevent more than one motor-driven load 25 horsepower or larger in the same facility from starting concurrently:
      a) When starting one load, inhibit start logic for all other such equipment until the load being started is up to speed (RVSS or VFD), or after a setpoint time delay (full-voltage starters and miscellaneous equipment).

j. Speed control:
   1) Modulate speed on VFD-driven motors using jog and hold, or PID control algorithms to maintain process conditions as described in the specific loop descriptions.
   2) Operate speed control within a pre-defined range:
      a) Minimum speed as determined by equipment manufacturer. The higher of:
         (1) Minimum motor speed to maintain adequate cooling for the type of load driven (constant or variable torque).
         (2) Minimum equipment speed, such as minimum speed to deliver flow or to deliver minimum flow for equipment cooling or lubrication.
      b) Maximum speed 100 percent (60 hertz) or as identified by equipment manufacturer.

3) Where multiple equipment may operate together to maintain the same process condition:
   a) Provide an operator selection for starting sequence.
   b) Start the first equipment at a preset starting speed.
   c) When one or more equipment is running and the speed control algorithm reaches a preset “Start Next” speed value (initially 95 percent of speed range) through a preset time delay:
      (1) Start the next available equipment at the preset starting speed.
      (2) Ramp up the started equipment and ramp down the previously running equipment to the mid operating speed (adjustable in the PLC). Determine preset values for each condition based on equipment and system characteristics to provide approximately the same total flow or process condition with the new load running at the mid speed (for example if one pump is running and the second pump will be added, then the total flow of both pumps running at mid
operating speed should be approximately the same as flow of one pump at Start Next speed).

(3) Once both equipment reach the mid operating speed, resume the speed control algorithm for those equipment.

(4) Operate all equipment at the same speed following the output of the speed control algorithm.

d) When two or more pieces of equipment are running, monitor for a “Stop Next” condition:

(1) Where flow rate is monitored, use a preset “Stop Next” flow rate for each possible number and combination of equipment:

(a) Determine initial “Stop Next” speed based on the flow that can be provided with one fewer piece of equipment running at a speed slightly below the “Start Next” speed.

(2) When the “Stop Next” condition exists through a preset time delay:

(a) Ramp speed of running equipment except for the equipment to be stopped up to a preset value based on the number of items running. Determine preset values for each condition based on equipment and system characteristics to provide approximately the same total flow or process condition with one fewer load running (typically slightly below the preset “Start Next” speed) while ramping speed of equipment to be stopped down to the preset minimum speed.

(b) Operate all remaining equipment at the same speed following the output of the speed control algorithm. Stop the load once it reaches minimum speed.

18. Gate and valve control:

a. Monitor the device’s LOCAL-STOP-REMOTE (LSR) switch(es) (the integral switch in the actuator or hard-wired switch at the local control station):

1) Display current REMOTE status on PCS screens.

b. Start an “Open Activation” timer whenever the device is expected to be open (PLC has issued an OPEN command in PCS AUTO, or OPEN was selected in PCS HAND):

1) Initially set “Open Activation” time to twice the normal opening time.

2) If the LSR position and open command do not change, and the PLC does not receive fully open status feedback within the “Open Activation” time period:

a) De-activate the open output.

b) Place the device in a “Failed” state.

c) Generate a “Failed to Open” alarm.
c. Start a “Close Activation” timer whenever the device is expected to be closed (PLC has issued a CLOSE command in PCS AUTO, or CLOSE was selected in PCS HAND):
   1) Initially set “Close Activation” time to twice the normal closing time.
   2) If the LSR position and close command do not change, and the PLC does not receive fully closed status feedback within the “Close Activation” time period:
      a) De-activate the close output.
      b) Place the device in a “Failed” state.
      c) Generate a “Failed to Close” alarm.

d. Limit the number of open/close commands so that it does not exceed the manufacturer requirements.

e. For modulating valves (valves controlled from either a 4-20 mA signal or digital communications command) with position feedback, start a “Position Error” timer whenever the position feedback differs from the required position command by more than a setpoint error when the LSR is in REMOTE:
   1) For analog modulating devices, error is determined by position feedback differing from position command by more than the setpoint error.
   2) For discrete modulating devices, error is determined by feedback not changing in the correct direction, or changing at less than a setpoint rate, when the OPEN or CLOSE PLC output is active.
   3) Initially set the “Position Error” time to 60 seconds.
   4) If the LSR position does not change, and position error stays outside of the setpoint error through the “Position Error” time period:
      a) Place the device in a “Failed” state.
      b) Generate a “Position Fail” alarm.

f. Provide separate time delay settings for each function and for each device.

g. If the valve position inputs indicate an invalid state (i.e., valve open and closed at the same time), place the device in a “Failed” state and generate an “Invalid State” alarm.

h. Re-establish PLC control of a device in a “Failed” state only after one of the following:
   1) An operator turns the device’s LSR switch out of REMOTE and back to REMOTE (i.e., REMOTE input to the PLC cycles off and back on).
   2) An operator acknowledges the fault from PCS.

i. For all alarm conditions, control other devices (as stopping pumps, etc.) as stated in the individual loop descriptions to make the system safe.

j. For discrete modulating valves (valves positioned to intermediate positions to control process values through discrete OPEN and CLOSE outputs), count the number of actuations (OPEN or CLOSE commands) per hour in the PLC:
   1) Display count on the HMI.
19. Power failure:
   a. Retain all operating setpoints during power failure.
   b. Restore plant operation to the state it was before the power loss:
      1) Store the operating state of all major equipment and systems in the
         PLC, and retain the last state during a power loss.

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL (NOT USED)

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING
   A. As specified in Section 17050 - Common Work Results for Process Control and
      Instrumentation Systems.

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION
SECTION 17101
SPECIFIC CONTROL STRATEGIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Loop descriptions:
      a. Specific control requirements and functional descriptions for individual control loops.

1.02 REFERENCES

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

1.03 DEFINITIONS

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

1.04 SYSTEM DESCRIPTION (NOT USED)

1.05 SUBMITTALS

A. Develop detailed loop descriptions based on the information in the Contract Documents, and submit as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
   1. For each control loop, provide a detailed functional description of the operation of the equipment, signals, and controls shown on the P&IDs:
      a. Include all functions depicted or described in the Contract Documents.
      b. Include the following within each loop description:
         1) All requirements specific to that loop.
         2) Common control requirements applicable to that loop.
         3) List of all ranges, setpoints, timers, values, counters, etc.
   2. Where there are similar loops with identical control, such as multiple loops for individual raw water pumps, only 1 loop description need be developed and the remaining loops may reference that loop description.
   3. Loop description format: As specified in this Section.

B. Loop number and title.
   1. References:
      a. List P&IDs that are specifically referenced.
2. Abstract:
   a. General description of how the loop works, what devices are involved, and how the process will be controlled.
   b. Process values, setpoints, and limits, including units and ranges:
      1) Show span and range values for analog inputs and outputs, and operating point and deadband for discrete inputs.

3. Hardwired control:
   a. Detailed description of the control functions at the local level.
   b. Function of local operator interfaces.
   c. Operation of hardwired field pilot controls:
      1) Pushbuttons.
      2) Selector switches.
      3) Potentiometers.
      4) Pilot lights, indicators, and other displays.

4. Hardwired interlocks:
   a. Explanation of the operation of system interlocks and hardwired permissive conditions.

5. PLC control:
   a. Detailed description of the control functions that are under control of the PLC.
   b. Operator controls and automatic controls.
   c. Setpoints, alarms, etc.:
      1) Include units and ranges for analog values.
      2) Include span and range for analog inputs and outputs.
      3) Include operating point and deadband for discrete inputs, and identify conditions where contacts are open, and when they close.
   d. Control sequences.
   e. Software interlocks:
      1) Operation of system software interlocks.

6. PCS/LOI/HMI control:
   a. Detailed description of the operator controls.
   b. Setpoints, alarms, etc.

7. Indicators and alarms:
   a. List any indicators and alarms specific to the loop that are not covered in the common control strategies.

8. Failure modes:
   a. List any failure modes specific to the loop that are not covered in the common control strategies.

1.06 QUALITY ASSURANCE (NOT USED)

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)
1.10 SCHEDULING (NOT USED)

1.11 WARRANTY (NOT USED)

1.12 SYSTEM START-UP (NOT USED)

1.13 DISTRICT’S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2  PRODUCTS

Not Used.

PART 3  EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION (NOT USED)

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION

A. Loop 24.1000 - Storm Drain Pump Station:
   1. References:
      a. 24N01.
   2. Abstract:
      a. Vendor package pump station incorporating 2 submersible pumps
         operating in a duty/standby configuration, 1 pressure transducer level
         transmitter, and high-high and low-low level float switches. The pump
         station pumps liquids from the stormwater wet well to the
         out-of-compliance pond.
   3. Hardwired control:
      a. As indicated in Section 11312J - Submersible Process Liquid Sump Pumps.
   4. Hardwired interlocks/overload programmed interlocks:
      a. All pumps are stopped if the low-low level switch is activated.
   5. PLC control:
      a. As indicated in Section 11312J - Submersible Process Liquid Sump Pumps.
   6. PCS/LOI/HMI control:
      a. None.
   7. Indicators and alarms:
      a. As indicated on the Drawings and specified in Section 17100 - Control
         Strategies.
b. Vendor control panel provides monitoring signals including:
   1) Pump 1 RUNNING.
   2) Pump 1 FAIL.
   3) Pump 2 RUNNING.
   4) Pump 3 FAIL.
   5) High-High Level Alarm.
   6) Low-Low Level Alarm.
   7) Stormwater Wet Well Level.
8. Failure modes:
   a. As indicated in Section 11312J - Submersible Process Liquid Sump Pumps.

B. Loop 41.1011 - Out-of-Compliance Diversion Gate:
   1. References:
      a. 41N01.
   2. Abstract:
      a. Motorized slide gate (Open/Close) to control flow from the out-of-compliance wet well to the out-of-compliance pond.
   3. Hardwired control:
      a. With the LSR switch in LOCAL position, the gate is controlled by the Open and Close pushbuttons.
   4. Hardwired interlocks/overload programmed interlocks:
      a. None.
   5. PLC control:
      a. Existing PLC controls for the Out-of-Compliance Diversion Valve shall be reassigned to the Out-of-Compliance Diversion Gate.
   6. PCS/LOI/HMI control:
      a. When the LSR switch is in REMOTE position, Open and Close selectors on the HMI will be used to set the gate position.
   7. Indicators and alarms:
      a. Provide Fail to Open and Fail to Close alarms
   8. Failure modes:
      a. As indicated on the Drawings and specified in Section 17100 - Control Strategies.

C. Loop 41.1012 - Out of Compliance Isolation Gate:
   1. References:
      a. 41N01.
   2. Abstract:
      a. Motorized slide gate (Open/Close) to control flow from the out-of-compliance wet well to the out-of-compliance pond.
   3. Hardwired control:
      a. With the LSR switch in LOCAL position, the gate is controlled by the Open and Close pushbuttons.
   4. Hardwired interlocks/overload programmed interlocks:
      a. None.
5. **PLC control:**  
   a. Existing PLC controls for the existing Out-of-Compliance Isolation Gate shall be reassigned to the New Out-of-Compliance Isolation Gate.

6. **PCS/LOI/HMI control:**  
   a. When the LSR switch is in REMOTE position, Open and Close selectors on the HMI will be used to set the gate position.

7. **Indicators and alarms:**  
   a. Provide Fail to Open and Fail to Close alarms.

8. **Failure modes:**  
   a. As indicated on the Drawings and specified in Section 17100 - Control Strategies.

A. **Loop 45.1011 – Tertiary Effluent Pump Station, Perris Valley Pumps and Tertiary Effluent Pumps:**
   1. **References:**  
      a. Perris Valley Pump No.1 through 4 and Tertiary Effluent Pump No.1 and 2.
   2. **Abstract:**  
      a. Provide pressure/level and flow/level cascade control for the existing Perris Valley Pumps and Tertiary Effluent Pumps in addition to the existing control modes. The PLC shall control the Perris Valley and Tertiary Effluent Pump Discharge Pressure or Flow. The level controller shall modify pressure or level set point to maintain pump station level within an operator inputted range.
   3. **Hardwired control:**  
      a. Existing
   4. **Hardwired interlocks/overload programmed interlocks:**  
      a. Existing
   5. **PLC control:**  
      a. **Level/Flow Cascade Control**
         1) Existing
      b. **Pressure/Level Cascade Control**
         1) Pressure PID Controller
            a) Control Modes
               (1) **LOCAL AUTO**
                  (a) The operator enters a pressure setpoint (operator adjustable, psig) and selects the LEAD/LAG1/LAG2/LAG3/LAG4/LAG5 pump sequence for the Tertiary Effluent and Perris Valley Pumps in SCADA. Based on the pressure setpoint Plant PLC shall start and control the LEAD pump. If the LEAD pump is at the maximum speed but the pressure is less than the associated pressure setpoint then the LAG pump in the sequence will be started as defined below:
(b) If the FIC output is at the maximum speed, and after a PLC fixed time delay, then the next LAG pump in the sequence will be started as defined below:
(c) Start the LAG1, LAG2, LAG3, LAG4, LAG5 pump as needed
(d) Pump speed will increase to FIC output value as controller ramps the other pumps down.
(e) If the FIC output decreases to a lower PLC fixed value, and after a PLC fixed time delay, the process is reversed and the highest LAG pump will be stopped each time.

2) REMOTE AUTO
   (a) Pressure setpoint is received from Level Controller. Output clamps limit range of setpoint.
   (b) All control functions are same as LOCAL AUTO

2) Level PID Controller
   a) Operator enters Max and Min Level Setpoint clamps
   b) Gain and Integral set in PLC
   c) The Level Controller shall trim the Pressure Setpoint when the wet well level reaches the Max or Min Level Setpoint clamps.
   d) If the level reaches the Min Level Setpoint, the pressure will be decreased by an operator adjustable increment (i.e. 5 psig).
   e) If the level reaches the Max Level Setpoint, the pressure will be increased by an operator adjustable increment (i.e. 5 psig).
   f) Level trim updates will be performed every 30 seconds (operator adjustable) by the control system.

c. Flow/Level Cascade Control
   1) Flow PID Controller
      a) Control Modes
         (1) LOCAL AUTO
            (a) The operator enters a flow setpoint (operator adjustable, gpm) and selects the LEAD/LAG1/LAG2/LAG3/LAG4/LAG5 pump sequence for the Tertiary Effluent and Perris Valley Pumps in SCADA. Based on the flow setpoint Plant PLC shall start and control the LEAD pump. If the LEAD pump is at the maximum speed but the flow is less than the associated flow setpoint then the LAG pump in the sequence will be started as defined below:
            (b) If the FIC output is at the maximum speed, and after a PLC fixed time delay, then the next LAG pump in the sequence will be started as defined below:
            (c) Start the LAG1, LAG2, LAG3, LAG4, LAG5 pump as needed
(d) Pump speed will increase to FIC output value as controller ramps the other pumps down.
(e) If the FIC output decreases to a lower PLC fixed value, and after a PLC fixed time delay, the process is reversed and the highest LAG pump will be stopped each time.

2) REMOTE AUTO
   (a) Flow setpoint is received from Level Controller. Output clamps limit range of setpoint.
   (b) All control functions are same as LOCAL AUTO

2) Level PID Controller
   a) Operator enters Max and Min Level Setpoint clamps
   b) Gain and Integral set in PLC
   c) The Level Controller shall trim the Flow Setpoint when the wet well level reaches the Max or Min Level Setpoint clamps.
   d) If the level reaches the Min Level Setpoint, the flow will be decreased by an operator adjustable increment (i.e. 100 gpm).
   e) If the level reaches the Max Level Setpoint, the flow will be increased by an operator adjustable increment (i.e. 100 gpm).
   f) Level trim updates will be performed every 30 seconds (operator adjustable) by the control system.

6. PCS/LOI/HMI control:
   a. Existing

7. Indicators and alarms:
   a. Existing

8. Failure modes:
   a. Existing

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL (NOT USED)

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING

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

3.11 PROTECTION (NOT USED)
3.12 SCHEDULES (NOT USED)

END OF SECTION
SECTION 17201
LEVEL MEASUREMENT: SWITCHES

PART 1  GENERAL

1.01  SUMMARY

A. Section includes:
   1. Ball float level switch.

B. Provide all instruments identified in the Contract Documents.

1.02  REFERENCES

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

1.03  DEFINITIONS

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

1.04  SUBMITTALS

A. Furnish submittals as specified in General Conditions and Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Provide complete documentation covering the traceability of all calibration instruments.

1.05  QUALITY ASSURANCE

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

B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials etc.
   2. Physical conditions:
      a. Installation and mounting requirements.
      b. Location within the process.
      c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
C. Notify the Engineer if any installation condition does not meet the instrument manufacturer’s recommendations or specifications.


1.06 DELIVERY, STORAGE, AND HANDLING

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

1.07 PROJECT OR SITE CONDITIONS

A. Project environmental conditions as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

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

1.09 MAINTENANCE

A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:

1. Ball float level switch:
   b. Evoqua Water Technologies, 9G-EF.
   c. ITT Flygt, Model ENM-10.
2.02 MANUFACTURED UNITS

A. Ball float level switch:
   1. General:
      a. Free hanging, encapsulated body with a switch to determine position of float.
   2. Element:
      a. Mechanical switch encapsulated in waterproof floating ball of nominal diameter, supported by flexible PVC cable and jacket or heavy neoprene.
      b. The length of the PVC cable shall be, at a minimum, equal to sump depth plus 5 feet.
      c. Float: Provide Type 316 stainless steel or polypropylene, maximum 3 inches in diameter.
      d. An operating temperature rating: -30 degrees Fahrenheit to +150 degrees Fahrenheit.
      e. Mercury switches are not acceptable.
      f. Lead wires: Mounted in flexible waterproof PVC cable from switch to junction box terminals without splices.
   3. Switch:
      a. Single pole double throw contacts rated 10 amps resistive at 120 VAC.
      b. Provide the number of floats per level system as indicated on the Drawings.
      c. Suspend ball float and adjust for level setpoint as required.
   4. Components:
      a. Floats shall include Type 316 stainless steel clamp and brackets and 1/4-inch cable to allow testing of the float without entering the basin or wet well.
      b. Provide strain relief at both ends of the float cable.

2.03 ACCESSORIES

A. Provide sunshades for outdoor installation.

2.04 SOURCE QUALITY CONTROL

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

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.
   1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer’s recommendations or specifications.
3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

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

3.04 FIELD QUALITY CONTROL

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

3.05 ADJUSTING

A. As specified in Section 17950 - Commissioning for Instrumentation and Controls.

3.06 CLEANING

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

3.07 DEMONSTRATION AND TRAINING

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

3.08 PROTECTION

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

3.09 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be as indicated on the Drawings, as specified in the Specifications, or both.

END OF SECTION
**LEVEL SWITCHES**

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**Project:** Tertiary Effluent Equalization Project

**Customer:** Eastern Municipal Water District

**Plant:** MVRWRF

**Location:** Riverside County, California

### General

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**Notes:** Refer to Section 17201 for additional level switch requirements.
SECTION 17404
PRESSURE/VACUUM MEASUREMENT: GAUGES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Pressure/vacuum gauges.

B. Provide all instruments specified in the Contract Documents.

1.02 REFERENCES

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

B. American Society of Mechanical Engineers (ASME):
   1. B40.100 - Pressure Gauges and Gauge Attachments.

1.03 DEFINITIONS

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

1.04 SUBMITTALS

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

B. Additional requirements:
   1. Product data:
      a. Accessories such as diaphragm seals, valve manifold, snubbers, and pulsation dampeners.

1.05 QUALITY ASSURANCE

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

B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
   2. Physical conditions:
      a. Installation and mounting requirements.
      b. Location within the process.
c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the Engineer if any installation condition does not meet the instrument manufacturer’s recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

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

1.07 PROJECT OR SITE CONDITIONS

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

1.08 WARRANTY

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

1.09 MAINTENANCE

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

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Ashcroft:
      a. Maximum pressure less than 10 pounds per square inch: Model 1188.
      b. Maximum pressure greater than or equal to 10 pounds per square inch: Model 1279.
   2. Wika.
   3. Ametek U.S. Gauge.

2.02 MANUFACTURED UNITS

A. General:
   1. Pressure gauge assembly shall include pressure sensing element, gauge case, and dial mechanism.

B. Performance requirements:
   1. Pressure range:
      a. As specified in the Contract Documents.
2. Accuracy:
   a. Grade 2A, as defined by ASME B40.100.
   b. Within 1.0 percent of span after friction errors are eliminated by tapping or vibration.
   c. Maximum allowable friction inaccuracy: Within 1.0 percent of span.
3. Element:
   a. Where the maximum pressure is less than 10 pounds per square inch, provide socket and bellows; for all other pressure ranges, employ a Bourdon® tube.
   b. Socket tips for bellows and Bourdon® tube:
      1) Materials: Type 316 stainless steel.
   c. Overpressure: Minimum 130 percent of maximum range pressure without damage to gauge or sensing element.
   d. Wetted materials: Type 316 stainless steel.
4. Dial gauge:
   a. Dial size: 4-1/2 inches.
   b. Dial case material:
      1) Maximum pressure less than 10 pounds per square inch:
         a) Phenolic.
      2) Maximum pressure greater than or equal to 10 pounds per square inch:
         a) Phenolic.
   c. Provide safety gauge with safety blow out through the back or top of the unit.
   d. Dial face: Gasketed shatterproof glass or polycarbonate.
   e. Provide gauge locks on all pressure gauges directly connected to diaphragm seals.
   f. Provide gauge locks where possible.
   g. Connection and mounting:
      1) Direct mounted and suitable for outdoor installation.
      2) 1/2-inch NPT.
      3) Connection material: Stainless steel.
   h. Pointer: Externally adjustable.

2.03 ACCESSORIES

A. Pulsation dampeners and snubbers:
   1. Provide pulsation dampener or snubber with each pressure gauge installed on discharge of positive displacement type pump.
   2. Provide piston-type snubber if pressure spikes will exceed 130 percent of gauge maximum range.
   4. Mount pulsation dampener or snubber integrally to the pressure gauge.
   5. Connection: 1/2-inch NPT.
B. Provide diaphragm seals as specified in the Contract Documents:
   1. Diaphragm seal and pressure gauge shall be assembled by manufacturer and shipped as an assembly.

### 2.04 SOURCE QUALITY CONTROL

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

B. Factory calibrate each pressure gauge at a facility that is traceable to the NIST.

C. Provide complete documentation covering the traceability of all calibration instruments.

### PART 3 EXECUTION

#### 3.01 EXAMINATION (NOT USED)

#### 3.02 PREPARATION (NOT USED)

#### 3.03 INSTALLATION

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

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

#### 3.04 FIELD QUALITY CONTROL

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

#### 3.05 ADJUSTING

A. Verify factory calibration of all instruments in accordance with the manufacturer’s instructions:
   1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

#### 3.06 CLEANING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
3.07 DEMONSTRATION AND TRAINING

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

3.08 PROTECTION

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

3.09 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION
# Pressure Gauges Specifications

**A/E:** Carollo Engineers

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**Contractor:**

**Project:** Tertiary Effluent Equalization Project

**Customer:** Eastern Municipal Water District

**Plant:** MVRWRF

**Location:** Riverside County, California

**BOM No.:**

**File:**

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Note 1: Include diaphragm seal
SECTION 17407
PRESSURE MEASUREMENT: SUBMERSIBLE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Submersible pressure transmitters.

B. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

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

1.03 DEFINITIONS

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

1.04 SUBMITTALS

A. Furnish submittals as specified in General Conditions, and Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

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

B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials etc.
   2. Physical conditions:
      a. Installation and mounting requirements.
      b. Location within the process.
      c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
C. Notify the Engineer if any installation condition does not meet the instrument manufacturer’s recommendations or specifications.

D. Provide instruments manufactured at facilities certified to the quality standards of ISO 9001.

1.06 DELIVERY, STORAGE, AND HANDLING

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

1.07 PROJECT OR SITE CONDITIONS

A. Project environmental conditions as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
   1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

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

1.09 MAINTENANCE

A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Submersible level measurement with 2-wire integral transmitter:
   1. One of the following or equal:
      a. Endress+Hauser, Waterpilot FMX21 with 1.65-inch outer diameter probe.
      b. GE Druck, PTX-1290.
      c. Siemens, A1000i.

2.02 MANUFACTURED UNITS

A. Submersible level measurement with 2-wire integral transmitter:
   1. General:
      a. Pressure is measured through a diaphragm-type measuring cell and converted to linear pressure measurement.
b. Each submersible pressure transmitter system shall include:
   1) Signal cable, including pressure compensation tube.
   2) Transducer probe with integral transmitter.
   3) Transmitter cable termination box.

2. Performance requirements:
   a. Accuracy:
      1) 0.3 percent of range.
   b. Repeatability:
      1) 0.25 percent of full scale.
   c. Rangeability:
      1) 3:1.
   d. Range:
      1) As indicated on the contract documents.

3. Element:
   a. Sensor housing shall be Type 316L stainless steel or titanium with ceramic, teflon-coated, or titanium diaphragm.
   b. Protective cap shall be manufacturer’s recommended material, chemically resistant to process fluid.
   c. Slip resistant extension cable with pressure compensation tube with Teflon filter.
   d. Enclosure for probe and transmitter assembly shall be NEMA Type 6P.

4. Transmitter:
   a. Power supply:
      1) 24 VDC: 2 wire loop powered.
      2) Power consumption: 18 VA maximum.
   b. Outputs:
      1) Isolated 4 to 20 milliamperes DC.
   c. Without display.
   d. Ambient operating temperature limits of -10 to 70 degrees Celsius (-14 to 158 degrees Fahrenheit).
   e. Transmitter shall be integral to probe housing.

5. Transmitter cable termination box:
   a. NEMA Type 4X.
   b. Equipped with filter or desiccant chamber to eliminate moisture from the pressure compensation tube.
   c. Termination for signal wires and pressure compensation tube.

2.03 ACCESSORIES

A. Type 316L stainless steel mounting clamp with Type 304 stainless steel mounting screws.

B. Provide guide tube for stillwell mounting.

C. Provide cable clamp and strain relief.
D. Provide computer cable adapter with Windows® software.
E. Provide sunshade for outdoor installations.
F. Provide integral surge protection per Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

2.04 SOURCE QUALITY CONTROL
A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
B. Factory calibrate each instrument with a minimum 3-point calibration or according to Manufacturer’s standard at a facility that is traceable to the NIST.
   1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the project site.

PART 3 EXECUTION
3.01 EXAMINATION
A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.
   1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer’s recommendations or specifications.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION
A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL
A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.05 ADJUSTING
A. As specified in Section 17950 - Commissioning for Instrumentation and Controls.
3.06 CLEANING

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

3.07 DEMONSTRATION AND TRAINING

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

3.08 PROTECTION

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

3.09 SCHEDULES

A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
   1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION
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**A/E:** Carollo Engineers  
**Contractor:**  
**Project:** Tertiary Effluent Equalization Project  
**Customer:** Eastern Municipal Water District  
**Plant:** MVRWRF  
**Location:** Riverside, California  
**BOM No.:**  
**File:**

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<td>Accuracy</td>
<td>0.3 % of range</td>
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<td>Endress Hauser</td>
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<td></td>
</tr>
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<td>36</td>
<td>Other</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**  
Include signal isolator
SECTION 17710

CONTROL SYSTEMS: PANELS, ENCLOSURES, AND PANEL COMPONENTS

PART 1   GENERAL

1.01    SUMMARY

A. Section includes:
   1. Design, fabrication and assembly of all instrumentation enclosures, control
      panels and components provided under this contract, including but not
      limited to:
      a. Custom built instrumentation and control panels, including all enclosures
         for hand stations controllers, low voltage power distribution and
         marshalling panels.
      b. Control panels furnished as part of equipment systems specified in other
         Divisions, such as vendor control panels (VCPs) and chemical feed panels.
      c. Control components.
      d. Control panel installation.

B. Provide all control panels identified in Contract Documents.

1.02    REFERENCES

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

B. Institute of Electrical and Electronics Engineers (IEEE):
      AC Power Circuits.

C. Underwriters Laboratories Inc. (UL):
   1. 508 - Standard for Industrial Control Equipment.
   2. 508A - Standard for Industrial Control Panel.
   3. 913 - Standard for Intrinsically Safe Apparatus and Associated Apparatus for
      Use in Class I, II, III, Division 1, Hazardous (Classified) Locations.
   4. 1283 - Standard for Electromagnetic Interference Filters.
   5. 1449 - Standard for Surge Protective Devices.

1.03    DEFINITIONS

A. As specified in Section 17050 - Common Work Results for Process Control and
   Instrumentation Systems.
B. Specific definitions:
1. The term “panel” in this Section is interchangeable with the term “enclosure.”

1.04 SYSTEM DESCRIPTION

A. Panel dimensions:
1. Minimum dimensions are scalable from or as indicated on the Drawings and are based upon manufacturer’s non-certified information. It is the responsibility of the Contractor or manufacturer to design and size all panels:
   a. Size panels to provide space for all equipment, wiring, terminations, and other items in the panel, including space for future build out.
   b. Panel sizes that substantially deviate (within 3 inches in any dimension) from the sizes indicated on the Drawings must be approved by the Engineer.
   c. Maximum panel depth: 30 inches, unless otherwise indicated.

B. Structural design:
1. Completed and installed panel work shall safely withstand seismic requirements at the project site as specified in Section 16050 - Common Work Results for Electrical. Enclosures and internal equipment shall be braced to prevent damage from specified forces.

1.05 SUBMITTALS

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

B. Provide a control panel hardware submittal for each control panel and enclosure being provided on this project, including but not limited to:
1. Product data:
   a. Enclosure construction details and NEMA type.
   b. Manufacturer’s literature and specification data sheets for each type of equipment to be installed within or on the panel or enclosure.
2. Shop drawings:
   a. Scaled, detailed exterior panel (front and side views) and interior panel layout showing equipment arrangement and dimensional information:
      1) Provide draft for review and approval by Engineer. The Engineer has the authority to substantially alter initial panel layouts.
   b. Complete nameplate engraving schedule.
   c. Structural details of fabricated panels.
3. Calculations:
   a. Provide installation details based on calculated shear and tension forces:
      1) Calculations shall be signed and sealed by a Professional Engineer licensed in the state where the cabinets and panels will be installed.
b. For assembled enclosures and other equipment with a weight of 200 pounds or more, provide calculations for:
   1) Weight including panel internal components.
   2) Seismic forces and overturning moments.
   3) Shear and tension forces in connections.

c. Cooling calculations, including but not limited to:
   1) Highest expected ambient temperature for the enclosure’s location.
   2) Internal heat load.
   3) Exposure to direct sunlight.
   4) Dimensions of the enclosure in inches.
   5) Maximum allowable temperature inside the enclosure, based on the lowest operating temperature limit of the installed components.

C. Seismic design:
   1. Seismic panel construction:
      a. Seismic anchorage: Provide seismic design calculations and installation details for anchorage of all panels, enclosures, consoles, etc. to meet seismic requirements in Section 01612 - Seismic Design Criteria:
         1) Stamped by a Professional Engineer registered in the state where the project is being constructed.
      b. For floor-mounted freestanding panels weighing 200 pounds or more (assembled, including contents), submit calculations, data sheets, and other information to substantiate that panel, base, and framing meet minimum design strength requirements and seismic requirements as specified in Section 01612 - Seismic Design Criteria. Calculations shall be signed and sealed by a Professional Engineer licensed in the state where the cabinets and panels will be installed.

1.06 QUALITY ASSURANCE

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

B. Assemble panels, enclosures, and rack systems along with all internal and external devices, wiring, equipment, and materials in a facility that is recognized by UL to assemble and certify UL-labeled control panels:
   1. Provide all components and equipment with UL 508 listing.
   2. All control panels shall be UL 508A labeled, unless the equipment in the panel and the design in the contract documents cannot be reasonably modified to meet the requirements for UL 508A labeling:
   3. Provide fuses for all equipment that is not UL or UR listed.
1.07 DELIVERY, STORAGE, AND HANDLING

A. Project environmental conditions as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
   1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

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

1.12 SYSTEM START-UP (NOT USED)

1.13 DISTRICT’S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. As listed below in the individual component paragraphs.

B. Provide instruments and other components performing similar functions of the same type, model, or class, and from 1 manufacturer.

2.02 EXISTING PRODUCTS

A. Provide labor and materials for complete modifications to existing panels as required.
   1. Install District-provided PLC I/O modules in existing PLC/RIO panels.
2.03 MATERIALS

A. Construct and finish enclosures using materials capable of withstanding the mechanical, electrical, and thermal stresses, as well as the effects of humidity and corrosion that are likely to be encountered in normal service:

1. Enclosures shall have the following properties:
   a. NEMA Type 1: Steel.
   b. NEMA Type 4: Steel with gasketed door, raintight.
   c. NEMA Type 4X: Type 316 stainless steel (unless Type 304 is indicated on the Drawings).
   d. NEMA Type 4X: Polycarbonate or fiberglass reinforced polyester (FRP) in corrosive areas where stainless steel is incompatible.
   e. NEMA Type 12: Steel with gasketed door, dusttight.
   f. NEMA Type 7: Cast aluminum.

B. Bolting material:
   1. Commercial quality 1/2-inch diameter, stainless steel hex-head Grade 5 bolts, nuts, and washers, with unified coarse (UNC) threads.
   2. Carriage bolts for attaching end plates.
   3. All other bolted joints shall have S.A.E. standard lock washers.

2.04 MANUFACTURED UNITS

A. Panels/enclosures:
   1. Manufacturers: One of the following or equal:
      a. Rittal.
      c. Saginaw Control & Engineering.
   2. Panel assembly:
      a. General guidelines for panel fabrication include:
         1) Continuous welds ground smooth.
         2) Exposed surfaces free of burrs and sharp edges.
         3) Base formed of heavy channel iron, either galvanized or powder coated, minimum 1/2-inch holes at 12-inch spacing to accommodate anchoring of freestanding enclosures to floor.
      b. Construct enclosure and mounting panel using stretcher-level quality sheet metal having minimum thickness not less than the following sizes (U.S. Standard Gauge):
<table>
<thead>
<tr>
<th>Enclosure Height (inches)</th>
<th>Minimum Enclosure Steel Thickness (gauge)</th>
<th>Minimum Back Mounting Panel Thickness (gauge)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall-mounted up to 48</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>Up to 57</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>57 - 69</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>69 - 82</td>
<td>12, except 10 on back</td>
<td>10</td>
</tr>
<tr>
<td>82 or more</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

1) Use heavier sheet metal to meet seismic requirements at the project site or when required due to equipment requirements.

C. Construct supporting frame structure with angled, channeled, or folded rigid section of sheet metal, rigidly attached to and having essentially the same outer dimensions as the enclosure surface and having sufficient torsional rigidity to resist the bending moments applied via the enclosure surface when it is deflected.

d. Provide stiffeners for back mounting panels in enclosures larger than 4 feet. In addition, secure the panels in place by collar studs welded to the enclosure.

e. Door construction:
   1) Turned-back edges suitably braced and supported to maintain alignment and rigidity without sagging.
   2) Sufficient width to permit door opening without interference with rear projection of flush-mounted instruments.
   3) Heavy-gauge piano-type continuous stainless steel hinges.
   4) For NEMA Type 12, Type 4, and Type 4X, provide oil-resistant neoprene sealing gasket and adhesive to seal cover to enclosure.
   5) Gasket installed to seal against roll lip on the enclosure opening.

f. Latches:
   1) For floor-mounted and freestanding panels, provide each door with a 3-point latching mechanism and locking handle with rollers on the ends of the latch rods. Latch rods shall be connected to a common door handle, hold doors securely, and form a compressed seal between door and gasket, at the top, side, and bottom.
      a) Provide padlock for each enclosure with padlock provisions.
   2) Include an oiltight key-locking, 3-point latching mechanism on each door:
      a) Provide 2 keys per panel.
      b) All locks keyed alike.
   3) For large NEMA Type 4 and NEMA Type 4X cabinets not available with 3-point latching hardware, provide multiple clips and padlock hasps.
g. Panel cut-outs:
   1) Cut, punch, or drill cutouts for instruments, devices, and windows. Smoothly finish with rounded edges.
   2) Allow a minimum of 3-inch envelope around all displays, controllers, and monitors.
   3) Reinforce around cut-outs with steel angles or flat bars for the following:
      a) Large panel cutouts; for example, openings for local operator interfaces.
      b) Pilot device groupings, where the removed metal exceeds 50 percent of the available metal.

3. In addition to the requirements specified above, the following requirements for NEMA Type 4X powder coated stainless steel enclosures apply:
   a. Minimum 14-gauge, Type 304 stainless steel.
   b. Captive stainless steel cover screws threaded into sealed wells.
   c. Inside finish: White polyester powder coating.
   d. Specifically designed for use with flange-mounted disconnect handles where required or as indicated on the Drawings.

4. Outdoor panels. Supplementary requirements for panels located outdoors are as follows:
   a. All enclosures located outdoors shall be explicitly designed and rated for outdoor service by the manufacturer.
   b. Door hardware: Stainless steel.
   c. Provide factory installed rain canopy and sun shield for all enclosures with operator interface panels.
   d. Bases: Heavy channel, gasketed stainless steel bases, flanges up, for anchoring to pad.

B. Arrangement of components:
   1. Maintain separation between 480VAC circuits, 120 VAC circuits, and 24VDC circuits.
   2. Arrange panel internal components for external conduit and piping to enter into panel either from above or below.
      a. Control panels installed outdoors to be bottom entry only.
   3. Arrange panel instruments and control devices in a logical configuration, associating pushbutton and selector switches with related readout devices, or as indicated on the Drawings.
   4. Mount internal control components on an internal back panel. Devices may be mounted on the side panel only by special permission from the Engineer.
   5. All control-panel-mounted operator interface devices shall be mounted between 3 feet and 5 feet above finished floor.
C. Overcurrent protection:
   1. Main overcurrent device:
      a. Where the electrical power supply voltage to the control panel is more
         than 120 VAC, provide the panel with a flange-mounted disconnect
         handle operating a molded-case circuit breaker and provide a control
         power transformer for 120-VAC circuits:
            1) Door-mounted disconnect handles are not acceptable.
            2) Mechanically interlock the disconnect switch with the control
               enclosure doors so that no door can be opened unless the power is
               disconnected, and the disconnect switch cannot be closed until all
               doors are closed.
            3) Provide means to defeat the interlock.
            4) Lockable in the off position.
      b. Control panels supplied with 120 VAC:
         1) Provide an internal breaker with the line side terminals covered by a
            barrier.
         2) Provide a nameplate prominently positioned on the control panel
            identifying the location of the power source and a warning
            statement requiring the source to be disconnected before opening
            the door to the enclosure.
   2. Provide circuit breakers as specified in Section 16412 - Low Voltage Molded
      Case Circuit Breakers.
   3. Selection and ratings of protective devices:
      a. Interrupting ratings: Not less than the system maximum available fault
         current at the point of application.
      b. Voltage rating: Not less than the voltage of the application.
      c. Select current rating and trip characteristics to be suitable for:
         1) Maximum normal operating current.
         2) Inrush characteristics.
         3) Coordination of the protective devices to each other and to the
            source breaker feeding the panel.
   4. Provide a separate protective device for each powered electrical device:
      a. An individual circuit breaker for each 120-VAC instrument installed within
         its respective control panel and clearly identified for function.
      b. An individual fuse for each PLC discrete output. Provide with individual
         blown fuse indication external of the I/O card:
            1) Size external fuse to open before any I/O-card-mounted fuses.
            2) Individual discrete inputs shall use a 0.5-ampere fuse.
      c. Control loops can use individual 5-ampere fuse for the loop.
      d. Install protective devices on the back mounting panel and identify by a
         service nameplate in accordance with the wiring diagrams.
5. Fuses for 4 to 20 milliamperes signals:
   a. Provide durable, readily visible label for each fuse, clearly indicating the correct type, size, and ratings of replacement fuse:
      1) Label shall not cover or interfere with equipment manufacturer's instructions.
   b. An individual 1/2-ampere fuse for each 4 to 20 milliamperes analog loop powered from the control panel.
   c. Provide fuses rated for the voltage and available short-circuit current at which they are applied.
   d. Manufacturers: One of the following or equal:
      1) Ferraz Shawmut.
      2) Littelfuse.
      3) Bussmann.

6. Fuse holders:
   a. Modular type:
      1) DIN rail mounting on 35-millimeter rail.
      2) Touch-safe design: All connection terminals to be protected against accidental touch.
      3) Incorporates blown-fuse indicator.
      4) Plug-in style fuse terminals and fuse plugs are not acceptable.
   b. Provide nameplate identifying each fuse:
      1) As specified in Section 16075 - Identification for Electrical Systems.
   c. Manufacturers: One of the following or equal:
      1) Phoenix Contact, UT4-HESI Series.
      2) Allen-Bradley, 1492-FB Series B.

7. Control circuit breakers:
   a. DIN rail mounting on 35-millimeter rail.
   c. Rated for 250 VAC.
   d. Interrupting rating: 10 kiloampere (kA) or available fault current at the line terminal, whichever is higher.
   e. Current ratings: As required for the application.
   f. Provide nameplate identifying each circuit breaker:
      1) As specified in Section 16075 - Identification for Electrical Systems.
   g. Manufacturers: One of the following or equal:
      1) Phoenix Contact, TMC Series.
      2) ABB.
      3) Allen-Bradley.
      4) Square D.

8. Electronic circuit protectors:
   a. Used where equipment is equipped with a NEC Class 2 power supplies requiring 100 watts to 8 amps.
   b. DIN rail mounting on 35-millimeter rail.
   c. Rated for 24 VDC.
   d. 4 channels to feed 4 independent power feeds to separate devices.
e. Output current ratings: As required for the application.

f. LED input status indication.

g. LED failure status of each channel indication.

h. Fail contacts.

i. Provide nameplate identifying each circuit breaker:
   1) As specified in Section 16075 - Identification for Electrical Systems.

j. Manufacturers: One of the following or equal:
   1) Rockwell Automation 1692-TD014.
   2) Puls PISA11 series.

D. Conductors and cables:

1. Power and control wiring:
   b. Insulation: 600 volts type MTW.
   c. Minimum sizes:
      1) Primary power distribution: 12 AWG.
      2) Secondary power distribution: 14 AWG.
      3) Control: 16 AWG.
   d. Color:
      1) AC power (line and load): Black.
      2) AC power (neutral): White.
      3) AC control: Red.
      4) AC control: Orange for foreign voltages.
      5) DC power and control (ungrounded): Blue.
      6) DC power and control (grounded): White with Blue stripe.
      7) Ground: Green.

2. Signal cables:
   b. Insulation: 600 volts, PVC outer jacket.
   c. Minimum size: 18 AWG paired triad.
   d. Overall aluminum shield (tape).
   e. Copper drain wire.
   f. Color:
      1) 2-Conductor:
         a) Positive (+): Black.
         b) Negative (-): White and red.
      2) 3-Conductor:
         a) Positive (+): Black.
         b) Negative (-): Red.
         c) Signal: White.
   g. Insulate the foil shielding and exposed drain wire for each signal cable with heat-shrink tubing.
E. Conductor identification:
   1. Identify each conductor and cable with unique wire numbers as specified in Section 16075 - Identification for Electrical Systems.
   2. Readily identified without twisting the conductor.

F. General wiring requirements:
   1. Wiring methods: Wiring methods and materials for panels shall be in accordance with the NEC requirements for General Purpose (no open wiring) unless otherwise specified.
   2. Install all components in accordance with the manufacturer’s instructions included in the listing and labeling.
   3. Provide a nameplate on the cover of the control panel identifying all sources of power supply and foreign voltages within the control panel.
   4. Provide transformers, protective devices, and power supplies required to convert the supply voltage to the needed utilization voltage.
   5. Provide power surge protection for all control panels.
   6. Provide signal surge protection within control panels for each analog I/O, discrete I/O, and data line (Copper Ethernet, Coax, Fieldbus signals) that originates from outdoor devices.
   7. Provide non-metallic ducts for routing and organization of conductors and cables:
      a. Provide wiring separation plan.
      b. Size ducts for ultimate build-out of the panel, or for 20 percent spare, whichever is greater.
      c. Provide separate ducts for signal and low-voltage wiring from power and 120-VAC control wiring:
         1) 120 VAC: Grey colored ducts.
         2) 24 VDC: White colored ducts.
   8. Cables shall be fastened with cable-mounting clamps or with cable ties supported by any of the following methods:
      a. Screw-on cable tie mounts.
      b. Hammer-on cable-tie mounting clips.
      c. Fingers of the nonmetallic duct.
   9. Wire ties:
      a. No wire ties inside wire duct.
      b. Use Panduit Cable tie installation tool, with tension control/cutoff.
      c. Verify cut ends are cut flush filed smooth after installed.
   10. Provide supports at the ends of cables to prevent mechanical stresses at the termination of conductors.
   11. Support panel conductors where necessary to keep them in place.
   12. Wiring to rear terminals on panel-mount instruments shall be run in nonmetallic duct secured to horizontal brackets run adjacent to the instruments.
13. Conductors and cables shall be run from terminal to terminal without splice or joints. Exceptions:
   a. Factory-applied connectors molded onto cables shall be permitted. Such connectors shall not be considered as splices or joints.

14. The control panel shall be the source of power for all 120-VAC devices interconnected with the control panel including, but not limited to:
   a. Solenoid valves.
   b. Instruments both mounted in the control panel and remotely connected to the control panel.

G. Provide power circuits for all Contractor and Vendor-furnished PLC cabinets in accordance with the PLC and Instrument Power wiring diagrams Indicated on the Drawings or as specified.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS

A. Thermal management:
   1. Provide heating, cooling, and dehumidifying devices in order to maintain all instrumentation and control devices to within a range as specified in Section 01610 - Project Design Criteria.
   2. Air conditioner:
      a. Provide solid-state cabinet coolers or air conditioning units on all outdoor panels containing electronic components such as local operator interface (LOI) units, panel instruments, programmable logic controllers, or remote I/O.
      b. Provide filters on intake and exhaust openings.
      c. Increase panel sizes as needed to accommodate cooling units.
      d. Enclosure rating: NEMA Type 4X.
      e. Manufacturers: The following or equal:
         1) Kooltronic, Guardian DP Series.
         2) ICEqube, Blade series or IECEx/ATEX for Zone 1 & 2.
   3. Heating:
      a. Provide all panels located in areas that are not climate controlled with thermostatically controlled strip heaters, except where all of the following conditions apply:
         1) The panel is not supplied with 120 VAC power.
         2) There are no electronics or moisture-sensitive devices in the enclosure.
         3) The panel is smaller than 38 inches high.
   4. Heat exchanger:
      a. Closed-loop design ensuring separation of ambient air and clean air inside the cabinet.
      b. Filterless design to facilitate easy cleaning of the core.
      c. Mounting: As indicated on the Drawings.
d. Manufacturers: The following or equal:
   1) Noren, CC Series.
   2) ICEqube, Blade series.

5. Enclosure temperature switch:
   a. Provide wall-mounted bimetallic switch transmitter (to measure internal
      cabinet temperature in all enclosures) containing electrical components
      such as PLCs, RTUs, RIO, and VFDs.
   b. Sensor and electronic enclosure.
   c. Accuracy: Within 2 degrees Fahrenheit.
   d. Single contact:
      1) Manufacturers: One of the following or equal:
         a) Hoffman ATEMNC.
         b) Pfannenberg FLZ.
   e. Dual contact:
      1) Manufacturers: The following or equal:
         a) Hoffman/Penair ADLTEMP.

6. Status relays and discrete inputs for switches, power supplies, and fieldbus
   devices (if applicable):
   a. Provide as indicated on the Drawings or as specified.

B. Panel meters:
   1. Pointer type:
      a. Suitable for panel mounting.
      b. Minimum scale length: 3 inches.
      c. Calibrated in engineering units.
      d. Accuracy: Within 2 percent of span.
      e. NEMA Type 4/IP65 sealed front metal bezel.
      f. Manufacturers: One of the following or equal:
         1) Yokogawa.
         2) Red Lion.

   2. Digital process indicators:
      a. General:
         1) Integral provisions for scaling.
         2) Scale to process engineering units.
         3) Switch-programmable decimal points.
         4) NEMA Type 4/IP65 sealed front bezel.
      b. Current and voltage indicators:
         1) 3-1/2-digit minimum.
         2) Minimum character height: 0.5 inch.
         3) Accuracy:
            a) AC/DC volts: Within 0.1 percent of reading plus 2 digits.
            b) DC current: 4 to 20 milliamperes; within 0.1 percent of reading
               plus 1 digit.
            c) DC voltage: 0 to 10 volts; within 0.1 percent of reading plus
               1 digit.
c. Operating voltage: 120 VAC.
d. Operating temperature: 0 to 60 degrees Celsius.
   1) Manufacturers: One of the following or equal:
      a) Red Lion.
      b) Action Instruments, Visipak.
3. Digital bar graph meter:
   a. Self-contained instruments that display process signals directly in
      engineering units, both in decimal format and as a bar graph display.
   b. Suitable for panel mounting.
   c. LED display:
      1) Not less than 3 decimal digits.
      2) Not less than a 101-segment LED bar graph.
   d. Input signal:
      1) All conventional current loops and voltage control signals.
   e. Minimum sample rate of once per second.
   f. Provisions for field-adjustable scaling and/or offset.
   g. Accuracy shall be within 1 least-significant digit.
   h. Manufacturers: One of the following or equal:
      1) Ametek Dixson.
      2) Yokogawa.
      3) Weschler Instruments.
4. Counters:
   a. 6 digits.
   b. Switch-selectable inputs:
      1) Switch contacts.
      2) CMOS.
      3) TTL.
      4) Magnetic pickup.
      5) RLC sensors.
   c. Selectable up/down control via external signal.
   d. Remote reset.
   e. Remote inhibit to prevent accumulating counts.
   f. Programmable to enable or disable front panel reset.
   g. Non-volatile memory to retain all data upon loss of supply power.
   h. Sunlight readable.
   i. Operating temperature: 0 to 50 degrees Celsius.
   j. Manufacturers: The following or equal:
      1) Red Lion, PAX Series.
C. Pilot devices:
   1. General:
      a. Provide operator pushbuttons, switches, and pilot lights, from a single
         manufacturer.
      b. Size:
         1) 30.5 millimeters.
c. Heavy duty.

d. Pushbuttons:
   1) Contacts rated:
      a) NEMA Type A600.
   2) Furnish 1 spare normally open contact and normally closed contact with each switch.

e. Selector switches:
   1) Contacts rated:
      a) NEMA Type A600.
      b) Knob type.
   2) Furnish 1 spare normally open contact and normally closed contact with each switch.
   3) Provisions for locking in the OFF position where lockout provisions are indicated on the Drawings.

f. Pilot lights:
   1) Type:
      a) LED for interior installations.
   2) Push to test.
   3) Lamp color:
      a) On/Running/Start: Red.
      b) Off/Stop: Green.
      c) Power: White.
      d) Alarm: Amber.
      e) Status or normal condition: White.
      f) Opened: Red.
      g) Closed: Green.
      h) Failure: Red.

2. Indoor and outdoor areas:
   a. NEMA Type 4/13.
   b. Manufacturers: One of the following or equal:
      1) Allen-Bradley, Type 800T.
      2) Schneider Electric, Class 9001, Type K.
      3) General Electric, Type CR104P.
      4) IDEC, TWTD Series.

3. Corrosive areas:
   a. NEMA Type 4X.
   b. Corrosion resistant.
   c. Exterior parts of high-impact strength fiberglass-reinforced polyester or multiple-layer epoxy-coated zinc.
   d. Manufacturers: One of the following or equal:
      1) Cutler Hammer, Type E34.
      2) Schneider Electric, Class 9001, Type SK.
      3) Allen-Bradley Type 800H.
      4) IDEC, TWTD Series.
4. Hazardous (Classified) Areas/Class I Division 2:
   a. NEMA Type 4X.
   b. Corrosion resistant.
   c. Exterior parts of high-impact strength fiberglass-reinforced polyester or multiple-layer epoxy-coated zinc:
      1) All contacts contained within a hermetically sealed chamber:
         a) Pushbuttons.
         b) Selector switches.
         c) Push-to-test contacts on pilot lights.
      2) UL listed and labeled for Class I Division 2 areas.
   d. Manufacturers: One of the following or equal:
      1) Cutler Hammer, Type E34.
      2) Allen-Bradley, Type 800H.

D. Signal isolators and converters:
   1. Furnish signal isolators that provide complete isolation of input, output, and power input:
      a. Minimum isolation level: 1.0 kilovolts AC/50 hertz for at least 1 minute.
      b. Adjustable span and zero.
      c. Accuracy: Within 1.0 percent of span.
      d. Ambient temperature range: -20 to +65 degrees Celsius.
   2. Manufacturers: One of the following or equal:
      a. Phoenix Contact, Mini Analog Pro.
      b. Acromag, 1500, 600T, 800T, Flat Pack, or ACR Series.
      c. Action Instruments, Q500 Series or Ultra SlimPakII.
      d. AGM Electronics, Model TA-4000.
      e. Moore Industries, MIT 4-Channel.

E. Relays:
   1. General:
      a. For all types of 120-VAC relays, provide surge protection across the coil of each relay.
      b. For all types of 24-VDC relays, provide a free-wheeling diode across the coil of each relay.
      c. For plug in type relays, provide a relay base from the same manufacturer as the relay manufacturer.
   2. General purpose:
      a. Magnetic control relays.
      b. NEMA ratings:
         1) 300 volts.
         2) 10 Amps continuous (minimum).
         3) 7,200 volt-ampere make.
         4) 720 volt-ampere break.
      c. Plug-in type.
      d. LED indication for energization status.
e. Coil voltages: As required for the application.
f. Minimum poles: DPDT.
g. Touch-safe design: All connection terminals to be protected against accidental touch.
h. Enclose each relay in a clear plastic heat and shock-resistant dust cover.
i. Quantity and type of contact shall be as indicated on the Drawings or as needed for system compatibility.
j. Relays with screw-type socket terminals.
k. Provide additional (slave/interposing) relays when the following occurs:
   1) The number or type of contacts shown exceeds the contact capacity of the specified relays.
   2) Higher contact rating is required in order to interface with starter circuits or other equipment.
l. DIN rail mounting on 35-millimeter rail.
m. Ice-cube-type relays with retainer clips to secure relay in socket.
n. Integrated label holder for device labeling.
o. Manufacturers: One of the following or equal:
   1) Potter and Brumfield: Type KRP or KUP.
   3) Allen-Bradley: Type 700 HC.
   4) Square D: Type K.

3. Terminal block relays:
a. Magnetic control relays.
b. For use as an interposing relay for PLC based discrete I/O signals.
c. NEMA ratings:
   1) 250 volts.
   2) 6 Amps continuous.
   3) 1,500 volt-amperes make.
d. Plug-in type.
e. LED indication for energization status.
f. Coil voltages: As required for the application.
g. Minimum poles: SPDT.
h. Touch-safe design: All connection terminals to be protected against accidental touch.
i. Quantity and type of contact shall be as indicated on the Drawings or as needed for system compatibility.
j. Relays with screw-type socket terminals.
k. DIN rail mounting on 35-millimeter rail.
l. Integrated label holder for device labeling.
m. Manufacturer: One of the following or equal:
   1) Phoenix Contact PLC Series.
   2) Eaton XR TBR Series.
   3) IDEC RV8H Series.
   4) Allen-Bradley Type 700 HL TBR Series.
4. Latching:
   a. Magnetic-latching control relays.
   b. NEMA ratings:
      1) 300 volts.
      2) 5 Amps continuous.
      3) 360 volt-amperes make.
      4) 320 volt-amperes break.
   c. Plug-in type.
   d. DIN rail mounting on 35-millimeter rail.
   e. Coil voltage: As required for the application.
   f. Minimum poles: 2 PDT; as required for the application. Plus 1 spare pole.
   g. Touch-safe design: All connection terminals to be protected against accidental touch.
   h. Clear cover for visual inspection.
   i. Provide retainer clip to secure relay in socket.
   j. Manufacturers: One of the following or equal:
      1) Square D, 8501, Type K.
      2) IDEC, RR2KP Series.

5. Time delay:
   a. Provide time-delay relays to control contact transition time.
   b. Contact rating:
      1) 240 volts.
      2) 10 Amps continuous.
      3) 3,600 volt-amperes make.
      4) 360 volt-amperes break.
   c. Coil voltage: As required for the application.
   d. Provide pneumatic or electronic type with on-delay, off-delay, and on/off-delay:
      1) For off-delay, use true power-off time-delay relays. Where the required timing range exceeds capability of the off-delay relay use, signal off-delay where power loss will not cause undesirable operation or pneumatic time-delay relays.
   e. Minimum poles: 2 PDT.
   f. Units include adjustable dial with graduated scale covering the time range in each case.
   g. Minimum timing range: 0.1 seconds to 10 minutes, or as required for the application.
   h. Manufacturers: One of the following or equal:
      1) IDEC, RTE Series.
      2) Tyco Electronics (formerly Agastat), Series 7000 (pneumatic).
      3) Allen-Bradley, Type 700-HR.

F. Terminal blocks:
   1. DIN rail mounting on 35-millimeter rail.
   2. Suitable for specified AWG wire.
3. Rated for 15 amperes at 600 volts.
4. Screw terminal type.
5. Provide mechanism to prevent wire connection from loosening in environments where vibration is present. This mechanism shall not cause permanent deformation to the metal body.
7. Construction: Polyamide insulation material capable of withstanding temperature extremes from -40 to 105 degrees Celsius.
8. Terminals: Plainly identified to correspond with markings on the diagrams:
9. Disconnect-type field signal conductor terminals with socket/screw for testing.
10. Identify terminals suitable for use with more than 1 conductor.
11. Position:
   a. So that the internal and external wiring does not cross.
   b. To provide unobstructed access to the terminals and their conductors.
13. Manufacturers: One of the following or equal:
   a. Phoenix Contact, UT4 Series.
   b. Allen-Bradley, 1492 Series.

G. Wire duct:
1. Provide flame retardant plastic wiring duct, slotted with dust cover.
2. Type:
   a. Wide slot.
   b. Narrow slot.
   c. Round hole.
3. Manufacturers: The following or equal:
   a. Panduit.
   b. Phoenix Contact.
   c. Thomas & Betts.
   d. Iboco.

H. Din rail:
1. Perforated steel.
2. 35 mm width.
3. 15 mm deep.

I. Surge protection devices:
1. 120-volt control power for panels:
   a. Panels without a UPS:
      1) Provide surge protection device (SPD) for panel power entrances:
         a) Nominal 120-VAC with a nominal clamping voltage of 200 volts.
         b) Non-faulting and non-interrupting design.
         c) A response time of not more than 5 nanoseconds.
2) Control panel power system level protection, non-UPS powered:
   a) Designed to withstand a maximum 10-kA test current of an 8/20 µs waveform according to IEEE C62.41.1 Category C Area.
   b) For panels receiving power at 120 VAC, provide surge protection at secondary of main circuit breaker.
   c) Provide both normal mode noise protection (line to neutral) and common mode (neutral to ground) surge protection.
   d) DIN rail mounting.
   e) Attach wiring to the SPD by means of a screw-type cable-clamping terminal block:
      1) Gastight connections.
      2) The terminal block: Fabricated of non-ferrous, non-corrosive materials.
   f) Visual status indication of MOV status on the input and output circuits.
   g) Dry contact rated for at least 250 VAC, 1 Amp for remote status indication.
   h) Meeting the following requirements:
      1) Response time: Less than or equal to 100 ns.
      2) Attenuation: Greater than or equal to -40 dB at 100 kilovolt-hertz as determined by a standard 50-ohm insertion test.
      3) Safety approvals:
         a) UL 1283 (EMI/RFI Filter).
         b) UL 1449 2nd Edition.
   i) Manufacturers: One of the following or equal:
      1) Phoenix Contact, Type SFP Filter.
      2) Schneider Electric:
         a) ASCO, Model 277 (formerly Islatrol IE Series) Surge Protection Device.

b. Panels with a UPS:
   1) Provide surge protection on the control power source at each panel containing power supplies, or electronic components including PLCs, I/O, HMI, and digital meters.
   2) Location:
      a) For panels with a UPS, install surge protection ahead of UPS and maintenance bypass switch.
         1) Surge protection is not required for 120-VAC circuits that are only used for panel lights and receptacles.
   3) Maximum Continuous Operating Voltage: 150 VAC.
   4) Surge capability (8/20 µs wave): 10 kA.
   5) Peak let-through: 620V L-N, 850V L-G.
   6) Manufacturers: One of the following or equal:
      a) Phoenix Contact, Plugtrab SEC Series.
      b) MTL Surge Technologies, MA15 Series.
c. For panels receiving power at 480 VAC, provide surge protection on the 120-VAC control power transformer secondary.

2. Instrument, data, and signal line protectors (traditional I/O) - panel mounted:
   a. Surge protection minimum requirements: Withstand a 10-kA test current of an 8/20 µs waveform in accordance with IEEE C62.41.1 Category C Area.
   b. DIN rail mounting on 35-millimeter rail (except field-mounted SPDs).
   c. SPDs consisting of 2 parts:
      1) A base terminal block.
      2) A plug protection module:
         a) Replacing a plug shall not require the removal of any wires nor interrupt the signal.
         b) Base and plug coded to accept only the correct voltage plug.
   d. SPD:
      1) Manufacturers: One of the following or equal:
         a) Phoenix Contact, Plugtrab SEC Series.
         b) Bournes, Series 1800.

3. Instrument, data, and signal line protectors (traditional I/O) - field mounted:
   a. Surge protection minimum requirements: Withstand a minimum 10-kA test current of an 8/20 µs waveform in accordance with IEEE C62.41.1 Category C Area.
   b. Manufacturers: One of the following or equal:
      1) Phoenix Contact, Surgetrab Series.
      2) MTL, TP48 Series.

J. Horns and beacons:
   1. Beacons/horn combination units:
      a. Manufacturers: The following or equal:
         1) Edwards, Multi-Status LED 108i with tone module.
      b. LED Colors: Red, Green, and Amber.
      c. Power: 120VAC.
      d. Provide accessories such as pipe mount flange, pipe extensions, corner mount brackets, or wall mount brackets as needed.
      e. Horn rated 80 dB minimum at 10 feet.
   2. Dedicated beacon unit:
      a. Manufacturers: One of the following or equal:
         2) Allen-Bradley, 855 B *-* 10 Series.
         3) Edwards, 102 Series.
   3. Dedicated horn unit:
      a. Electromechanical:
         1) Manufacturers: One of the following or equal:
            a) Federal Signal, 350 or 31X Series.
            b) Edwards, 878EX or 879EX Series.
b. Electronic:
   1) Manufacturers: One of the following or equal:
      a) Federal Signal, 300GCX or 300X Series.
      b) Allen-Bradley, 855H or 855XH Series.
      c) Edwards, 5530M or 5533MD Series.
   c) Rated for 80 dB minimum at 10 feet.

K. Power supplies:
   1. Design power supply system so that either the primary or backup supply can
      be removed, repaired or replaced, and returned to service without disrupting
      the system operation.
   2. Convert 120 VAC to 24-volt DC or other DC voltages required or as required
      for the application.
   3. Provide redundant backup 24 VDC power supply units to automatically supply
      the load upon failure of the primary supply.
   4. Provide power supply arrangement that is configured with several modules to
      supply adequate power in the event of a single module failure in either a 1+1
      or N+1 configuration as required:
      a. Provide automatic switchover upon module failure.
      b. Alarm contacts monitored by the PLC.
   5. Provide protective isolation between power supply units either by means of
      Diodes, Diode Modules, MOSFET Modules, or use power supplies with built in
      redundancy. Power supplies with built in redundancy must actively isolate
      each power supply and be designed as such.
   6. Sized to provide 40-percent excess rated capacity.
   7. UL 508C listed to allow full-rated output without de-rating.
   8. Provide fuse or short-circuit protection.
   9. Provide a minimum of 1 set of dry contacts for each power supply configured
      to change state on failure for monitoring and signaling purposes.
   10. Output regulation: Within 0.05 percent for a 10-percent line change or a
       50-percent load change.
   11. Operating temperature range: 0 to 60 degrees Celsius.
   12. Touch-safe design: All connection terminals to be protected against accidental
       touch.
   13. DIN rail mounting on 35-millimeter rail:
       a. Mount the power supply in the proper orientation as recommended by
          the manufacturer to ensure adequate thermal dispersion without
          derating the power supply.
   14. Provide self-protecting power supplies with a means of limiting DC current in
       case of short circuit.
   15. Manufacturers: One of the following or equal:
       a. Fully redundant:
          1) Phoenix Contact, Quint Power Supply with SFB technology.
             a) Phoenix Contact, Quint.
          2) IDEC, PS5R Series.
3) Sola.
4) PULS.

b. Redundancy module:
   1) Phoenix contact, o-ring redundancy module.

L. Intrinsic safety barriers:
   1. Transformer isolated barrier:
      a. Containing a transformer to provide complete:
         1) Isolation between the safe and hazardous areas for loop-powered devices.
         2) 3-way isolation between the safe area, hazardous area, and power supply powered devices.
      b. Resistor for current limitation.
      c. Fuses for short-circuit protection.
      d. Provide barriers with pluggable connectors that are coded for easy replacement.
      e. Transmission error shall be less than or equal to 0.1 percent of full-scale.
      f. DIN rail mounting on 35-millimeter rail.
      g. Approvals:
         1) FM.
         2) UL 913.
   2. Types:
      a. Switch isolators:
         1) Designed and approved for use with discrete inputs.
         2) Supply power: 20 to 30 VDC.
         3) Output to track input.
         4) LED in the cover to indicate the status of the input.
         5) Selector switch to change the logic of the input.
         6) Input: Dry contact.
         7) Output: SPDT relay.
      b. Transmitter and converters for use with 4- to 20-millampere signals without Hart® communications capability:
         1) Designed and approved for use with 4- to 20-millampere analog signals.
         2) Designed for powering 2- and/or 3-wire transmitters in hazardous locations and repeating and/or generating the current to the safe area.
         3) Supply voltage: 20 to 30 VDC.
      c. Transmitter and converters for use with 4- to 20-millampere signals with Hart® communications capability:
         1) Designed and approved for use with 4- to 20-millampere analog signals.
         2) Designed for powering 2- and/or 3-wire transmitters in hazardous locations and repeating and/or generating the current to the safe area.
3) Transfer digital signals from the hazardous area to the safe area.
4) Complete bi-directional communication between a smart transmitter located in the field and the suitable equipment located in the safe area.
5) Supply voltage: 20 to 30 VDC.

3. Manufacturers: One of the following or equal:
   a. Phoenix Contact, MACX Series.
   b. Pepperl + Fuchs.

M. Starters:
1. Magnetic motor starters:
   a. As specified in Section 16422 - Motor Starters.
2. Integral self-protected starters:
   a. As specified in Section 16422 - Motor Starters.

N. Limit switches:
1. NEMA Type 4X.
2. AC contact rating 120 volts, 10 A.
3. DC contact rating 125 volts, 0.4 A.
4. Provide robust actuation mechanism not prone to degradation.
5. Provide complete actuator mechanism with all required hardware.
6. Allows for contact opening even during contact weld condition.
7. UL approved.
8. Operating temperature range: -18 to +110 degrees Celsius (0 to 230 degrees Fahrenheit).
9. Manufacturers: One of the following or equal:
   a. Allen-Bradley, 802 Series.
   b. Honeywell, HDLS Series.
   c. Omron, D4 Series.
   e. ABB.

O. Current switches:
1. Operate from 120-VAC supply voltage.
2. 1 normally open and normally closed contacts.
3. Adjustable current setting.
4. Manufacturers: The following or equal:
   a. Zelio®, RM35.
   b. Phoenix Contact, EMD Series.

P. Current transmitters:
1. Input current range: As indicated on the Drawings.
2. Output: 4-20 mA.
3. Operate from 24 VDC supply voltage.
4. Output overload protected.
5. Accuracy: Within 0.5 percent full-scale.
6. Ripple and noise: 1 percent maximum, peak to peak.
7. Frequency: 50/60 hertz.
8. Manufacturer:
   a. Phoenix Contact: Mini Analog Pro Series.

Q. Panel mount quick connector:
   1. Keyed insertion plug.
   2. Threaded cap to protect connection when not in use.
   4. Pre-wired pigtails.
   5. Indoor/Outdoor:
      a. Rating: Meets or exceeds panel rating.
      b. Manufacturers: One of the following or equal:
         1) Amphenol.
         2) Sealcon.
   6. Hazardous (Classified) Areas:
      a. UL listed and labeled for area as indicated on the Drawings.
      b. Manufacturers: The following or equal:
         1) Amphenol HDE Series.

2.07 ACCESSORIES

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

B. Provide panels with an inside protective pocket to hold the panel drawings. Ship panels with 1 copy of accepted Shop Drawings including, but not limited to, schematic diagram, connection diagram, and layout drawing of control wiring and components in a sealed plastic bag stored in the panel drawing pocket.

C. Provide 15-inch floor stands or legs where needed or as indicated on the Drawings.

D. Provide nameplate to each panel as indicated on the Drawings:
   1. Provide as specified in Section 16075 - Identification for Electrical Systems on all internal and external instruments and devices.
   2. Provide a nameplate with the following markings that is plainly visible after installation:
      a. Manufacturer’s name, trademark, or other descriptive marking by which the organization responsible for the panel can be identified.
      b. Supply voltage, phase, frequency, and full-load current.
      c. Power source or circuit ID.
      d. Short-circuit current rating of the panel based on one of the following:
         1) Short-circuit current rating of a listed and labeled assembly.
         2) Short-circuit current rating established utilizing an approved method.
E. Provide a window kit where indicated on the Drawings or where a transmitter with display is mounted inside a control panel. The window shall meet the following requirements:
1. Safety plate glass.
2. Secured by rubber locking seal.
3. Allow full viewing of devices issuing visual process data or diagnostics.

F. Lighting:
1. Provide 1 luminaire for each section, on the interior of the panel, spaced evenly along the top-front of the enclosure door opening(s):
   a. Covered or guarded.
   c. 120-volt, single-phase, 15-amp style plug.
   d. Provide 4,000 K, 900 Lumens - LED fixture.
      1) Provide additional fixtures for every 36 inches of width.

G. Receptacles:
1. Provide 1 duplex receptacle located every 4 feet of enclosure width, spaced evenly along the back mounting panels.
2. GFCI, 120-volt, single-phase, 15-amp style plug.
3. Provide circuit breaker or fuse to limit receptacle draw to 5 amperes.

H. Grounding:
1. Provide the following:
   a. Grounding strap between enclosure doors and the enclosure.
   b. Equipment grounding conductor terminals.
   c. Provide equipment ground bus with lugs for connection of all equipment grounding wires.
   d. Bond multi-section panels together with an equipment grounding conductor or an equivalent grounding bus.
2. Identify equipment grounding conductor terminals with the word “GROUND,” the letters “GND,” the letter “G,” or the color green.
3. Signal (24 VDC) grounding: Terminate each drain wire of a signal (shielded) cable to a unique grounding terminal block, or common ground bus at the end of the cable as shown on the Loop Drawings.
4. Ensure the continuity of the equipment grounding system by effective connections through conductors or structural members.
5. Design so that removing a device does not interrupt the continuity of the equipment-grounding circuit.
6. Provide an equipment-grounding terminal for each incoming power circuit, near the phase conductor terminal.
7. Size ground wires in accordance with NEC and UL Standards, unless noted otherwise.
8. Connect all exposed, noncurrent-carrying conductive parts, devices, and equipment to the equipment-grounding circuit.
9. Connect the door stud on the enclosures to an equipment-grounding terminal within the enclosure using an equipment-bonding jumper.
10. Bond together all remote and local control panels, processor racks, and conductive enclosures of power supplies and connect to the equipment-grounding circuit to provide a common ground reference.

I. Provide sunshades and insulation for all outdoor installations.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES

A. Finishes:
1. Metallic (non-stainless):
   a. Metal surfaces of panels shall be prepared by chemical cleaning and mechanical abrasion in accordance with the finish manufacturer’s recommendations to achieve a smooth, well-finished surface.
   b. Scratches or blemishes shall be filled before finishing. One coat of zinc phosphate shall be applied per the manufacturer’s recommended dry-film thickness and allowed to dry before applying the finish coat.
   c. Finish coat shall be a baked polyester-urethane powder, aliphatic air-dry polyurethane, or epoxy enamel to meet NEMA rating specified application.
   d. Exterior of enclosures located outdoors shall be UV-resistant polyester powder coating. Total dry film thickness shall be 3 mils, minimum.
2. Stainless steel:
   a. Stainless enclosures shall be provided with a Number 4 brushed finish - not painted.

B. Colors:
1. Exterior color of panels mounted indoors shall be manufacturer’s standard light gray.
2. Exterior of panels mounted outdoors shall be manufacturer’s standard white.
3. Panel interiors shall be manufacturer’s standard white.

2.11 SOURCE QUALITY CONTROL

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.
   1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer’s recommendations or specifications.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Install enclosures so that their surfaces are plumb and level within 1/8-inch over the entire surface of the panel; anchor securely to wall and structural supports at each corner, minimum. Direct attachment to drywall is not permitted.

B. Install the enclosure per guidelines and submitted installation instructions to meet the seismic requirements at the project site.

C. Provide floor stand kits for wall-mounted enclosures larger than 48 inches high.

D. Provide 3-1/2-inch high concrete housekeeping pads for freestanding enclosures.

E. Install gasket and sealing material under panels with floor slab cutouts for conduit:
   1. Undercoat floor-mounted panels.

F. Provide a full-size equipment-grounding conductor in accordance with NEC included with the power feeder. Terminate to the incoming power circuit-grounding terminal.

G. All holes for field conduits, etc. shall be cut in the field. There shall be no additional holes, factory cut holes, or hole closers allowed. Incorrect holes, additional holes, or mis-cut holes shall require that the entire enclosure be replaced.

H. Control panels that are adjacent to motor control centers shall be fully wired to the motor control centers using wireways integral to the motor control center or additional conduits as needed. These interconnections are not shown or reflected on the Conduit Schedule, but shall be shown on the Loop Drawings prepared by the Contractor.

I. Provide individually fused analog input module points with blown-fuse indicator lights, mounted external of the module on the output terminal strip.

J. Side panels:
   1. Side panels shall be kept free off all control equipment and devices. Any deviation must be sent to the engineer in writing asking for a deviation.
3.04 ERECTION, INSTALLATION, APPLICATION, AND CONSTRUCTION (NOT USED)

3.05 REPAIRS/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL
   A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING
   A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION
   A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.12 SCHEDULES (NOT USED)

   END OF SECTION
SECTION 17901

SCHEDULES: FIELD INSTRUMENTS

PART 1 GENERAL

1.01 SUMMARY

A. The Schedules Field Instrument is not a take-off list. Refer to Drawings and Specifications for additional information. Where any discrepancies between this list and the P&ID drawings arise, the P&ID shall govern.

B. Abbreviations used in the Instrument Index are defined on the Drawings.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 SCHEDULES FIELD INSTRUMENTS

A. Schedules Field Instruments attached.

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SECTION 17903
SCHEDULES: I/O LIST

PART 1 GENERAL

1.01 SUMMARY

A. The I/O list is not a take-off list. Additional information is as indicated on the Drawings and specified in the Contract Documents. Where any discrepancies between this list and the P&ID drawings arise, the P&ID shall govern.

B. Abbreviations used in the I/O list are defined on the Drawings.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 I/O LIST

A. I/O list attached.

END OF SECTION
### IO List

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April 2020
SECTION 17950
TESTING, CALIBRATION, AND COMMISSIONING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Testing requirements that apply to process control and instrumentation systems for the entire Project.

1.02 REFERENCES

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

B. Electronics Industries Alliance (EIA).

C. Telecommunications Industry Association (TIA).

1.03 DEFINITIONS

A. As specified in Sections 01756 - Commissioning and 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.04 SYSTEM DESCRIPTION (NOT USED)

1.05 SUBMITTALS

A. Furnish submittals as specified in General Conditions.

B. General:
   1. Reference additional detailed test submittal scheduling and prerequisite requirements as specified in the Sequencing article of Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

C. Overall test plan:
   1. Develop the PCIS system test submittals in consultation and cooperation with all applicable subcontractors.
   2. Develop and submit an overall testing plan for the PCIS. The overall test plan to be reviewed and approved by the Engineer before detailed test plans, procedures, and forms will be reviewed.
   3. Describe the test phases as they apply specifically to this Project and each process system.
   4. Provide a preliminary testing schedule to show the sequence of tests and commissioning as they apply to each process system and each PLC.
5. Provide a description of factory tests. Describe what equipment will be included, what testing equipment will be used, and the simulator that will be used.

6. Provide examples of proposed forms and checklists.

D. Test procedures:
1. Develop and submit detailed test procedures to show that the integrated SCADA system hardware and software is fully operational and in compliance with the requirements specified in the Contract Documents.
2. Provide a statement of test objectives for each test.
3. Prepare specific procedures for each process system.
4. Describe sequentially the steps to be followed in verifying the correct operation of each process system, including all features described in the loop descriptions, control strategies, and shown in the P&IDs. Implied or generic test procedures are not acceptable.
5. Specify who will perform the tests, specifically what testing equipment will be used (including serial numbers and NIST-traceable calibration), and how the testing equipment will be used.
6. Describe the expected role of the Engineer, as well as any requirements for assistance from District’s staff.
7. Provide the forms and checklists to be used.

E. Test forms:
1. Provide test and calibration forms and checklists for each of the following:
   a. Calibration.
   b. Factory acceptance tests (FAT).
   c. Loop validation tests.
   d. Installation tests.
   e. Functional tests.
   f. Instrumentation Fine-Tuning.
   g. Communication Testing including all digital bus and all forms of Ethernet.

2. Test forms shall include the detailed test procedures, or shall include clear references to separate pages containing the complete test procedure applicable to each form. If references to procedures are used, the complete procedure shall be included with each test binder.

3. Every page of each test form shall include project name, date, time, name of person conducting the test, signature of person conducting the test, and for witnessed tests, place for signature of person (Engineer and District) witnessing the test.

4. Some sample test forms are included at the end of this Section. These test forms show the minimum required test form content. They are not complete, and have not been customized for this Project. The Contractor is to develop and submit test forms customized for the Project and meeting all of the specified test and submittal requirements.
F. Testing binders:
   1. Sub-system to be tested, provide and submit a test binder containing all test procedures and individual test forms for the test. References to other documents for test procedures and requirements are not acceptable.
   2. Fill out in advance headings and all other information known before the test.
   3. Include applicable test plan information, as well as a list of all test prerequisites, test personnel, and equipment.
   4. Include or list reference material and provide separately at the time of the test.
   5. Record test results and verify that all test requirements and conditions have been met.

G. FAT procedure additional minimal requirements:
   1. Prepare and submit a FAT procedure which includes:
      a. Control system testing block diagram.
      b. Estimated test duration.
      c. Details on the simulator construction, components, and operation.

H. Test reports:
   1. At the conclusion of each test, submit a complete test report, including all test results and certifications.
   2. Include all completed test binders, forms, and checklists.
   3. Submission, review, and acceptance of each test report is required before the start of the sub-system.

1.06 QUALITY ASSURANCE

A. Test personnel:
   1. Furnish qualified technical personnel to perform all calibration, testing, and verification. The test personnel are required to be familiar with this Project and the equipment, software, and systems before being assigned to the test program.

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING

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

1.11 WARRANTY (NOT USED)

1.12 SYSTEM START-UP (NOT USED)
1.13  DISTRICT’S INSTRUCTIONS (NOT USED)

1.14  MAINTENANCE (NOT USED)

PART 2  PRODUCTS

2.01  MANUFACTURERS (NOT USED)

2.02  EXISTING PRODUCTS (NOT USED)

2.03  MATERIALS (NOT USED)

2.04  MANUFACTURED UNITS (NOT USED)

2.05  EQUIPMENT (NOT USED)

2.06  COMPONENTS (NOT USED)

2.07  ACCESSORIES (NOT USED)

2.08  MIXES (NOT USED)

2.09  FABRICATION (NOT USED)

2.10  FINISHES (NOT USED)

2.11  SOURCE QUALITY CONTROL

A. Source testing:
   1. Provide manufacturer services as specified in the table below.

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<th>Section Number</th>
<th>Section Title</th>
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<td>Common Work Results for Process Control and Instrumentation Systems</td>
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<td>17100 - Control Strategies</td>
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<td>17710 - Control Systems - Panels, Enclosures, and Panel Components.</td>
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<td>17950 - Testing, Calibration, and Commissioning</td>
<td>Testing, Calibration, and Commissioning</td>
<td>Witnessed</td>
</tr>
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</table>
2. **FAT - general:**
   a. Performed during the Commissioning Phase, source testing activity.
   b. Before shipment to the Project Site, the complete PCIS system including all operator stations, servers, network equipment, printers, PCMs, PLCs, RTUs, LCPs, CCS, peripherals, communications equipment, and other SCADA equipment, shall be assembled, connected, and all software loaded for a fully functional FAT of the integrated system.
   c. Perform tests to show that the integrated system hardware and software is fully operational and in compliance with the requirements specified in the Contract Documents.
   d. Additional factory tests are specified in other sections of the Instrumentation and Control Specifications.
   e. The FAT will be witnessed.
   f. Right of observation: The District retains the right to observe all factory test activities including any and all subsystem preparation, pretests, troubleshooting, retests, warm-up, and software modification and/or update.
   g. The District reserves the right to test any specified function, whether or not explicitly stated in the test submittal.
   h. Correction of deficiencies: Any deficiencies observed during the test shall be corrected and retested before completion of the test.
   i. Any changes and/or corrections shall be noted on the test forms. Engineer shall witness the revisions and/or corrections prior to leaving the test site.
   j. If the corrections and/or revisions are too extensive to be made while the Engineer is scheduled to be at the FAT test site, the FAT shall be, at the Engineer’s sole discretion, considered failed, and the test shall be restarted at a later date. All costs for the re-test shall be borne by the Contractor.

3. **Testing simulation:**
   a. The FAT shall make use of hardware simulators that contain switches, pilot lights, variable analog signal generators, and analog signal level displays, which shall be connected to the I/O points within the SCADA system. All inputs and outputs shall be simulated and proper control and system operation shall be validated.
   b. The use of jumper wires, terminal block mounted pilot lights, and loose meters to act as or supply the functionality of a simulator shall not be allowed.
   c. The hardware simulator may consist of a PLC, operating under a SCADA software package, or other approved software that has its I/O points wired to PLC’s I/O points. Software operating on a PC may then act as the switches, pilot lights, variable analog signal generators, and analog signal level displays.
4. Preliminary FAT:
   a. A complete preliminary FAT (pre-FAT) shall be conducted utilizing test procedures approved by the Engineer. The pre-FAT test procedure shall be a subset of the full FAT.
   b. The purpose of the pre-FAT is to provide assurance to the Engineer that the SCADA system is ready for the full, witnessed FAT, in terms of both stability and functionality. Debugging of software and troubleshooting of hardware shall occur during and before the pre-FAT, not during the FAT. The Contractor shall fully test the SCADA system and fix all deficiencies found before the full FAT.
   c. The District shall have the right to witness any or all of the pre-FAT testing and shall be notified in writing 20 days before the start of the pre-FAT.
   d. The pre-FAT test results submittal shall include a letter, signed by the Contractor’s project manager or company officer, certifying that the system is complete, has been tested successfully, and is fully ready for the full, witnessed FAT. The submittal shall include completed pre-FAT test forms, signed by the Contractor’s staff, and shall be submitted for review before the start of the FAT.

5. Panel inspections:
   a. The Engineer will inspect each control panel for completeness, workmanship, fit and finish, and compliance with the Contract Documents and the accepted shop drawings.
   b. Provide panel inspection forms as part of the FAT procedures submittal.
   c. Inspection to include, as a minimum: Layout, mounting, wire and data cable routing, wire tags, power supply, components and wiring, I/O components layout (including terminals, wiring and relays), device layout on doors and front panels, and proper ventilation operation.
   d. A sample FAT control panel form has been provided at the end of this Section.

6. I/O test:
   a. Verify that I/O is properly wired to field terminals and is properly mapped into the PLC and the rest of the SCADA system, including all operator interface devices.
   b. Test methodology:
      1) Discrete inputs: Apply appropriate input at panel terminal, observe input card indicator, and observe data value at each indicated data address. Observe data received on all operator interface displays (SCADA workstations and local operator interface (LOI) displays).
      2) Discrete outputs: Issue commands from operator interface screen, verify output card indicator light and measure response at field wiring terminals.
      3) Analog inputs: Apply appropriate analog input signal at panel terminals, observe data value at each indicated data address, and observe data properly received at each operator screen. Check each point at 0 percent, 50 percent, and 100 percent of scale.
4) Analog outputs: Enter scaled values in the output buffer file, observe the output data file value, and measure appropriate response at panel wiring terminals.

c. Test forms to include, but not be limited to:
   1) PLC and panel number.
   2) I/O type.
   3) I/O tag name.
   4) Panel terminal block numbers.
   5) Rack/slot/number of I/O point.
   6) Check-off for correct response for each I/O point.
   7) Space for comments.
   8) Initials of individual performing test.
   9) Date test was performed.
  10) Witness’ signature lines.

7. System configuration test:
   a. Demonstrate and test the setup and configuration of all operator stations, servers, development stations, and peripherals.
   b. Demonstrate all utility software and functions, such as virus protection, backup, optical drive burning, network monitoring, etc.
   c. Demonstrate the proper operation of all peripheral hardware.
   d. Demonstrate all general SCADA functions.
   e. Demonstrate proper operation of log-on and other access security functions.
   f. Demonstrate the proper operation of all historical data storage, trend, display, backup, and report functions.
   g. Test automatic fail over of redundant equipment.
   h. Demonstrate the proper operation of the alarm display and acknowledgement functions.
   i. Test forms:
      1) For each test, list the specification page and paragraph of the function demonstrated, and provide a description of the function.
      2) List the specific tests and steps to be conducted.
      3) For each function, list all of the different sub-functions or ways the function can be used, and provide a test check-off for each:
         a) Include signature and date lines.

8. Control logic test:
   a. The purpose of this test is to verify that all software functions and logic work as specified, along with any hardwired logic or functions in the tested control panels.
   b. Testing requirements:
      1) Demonstrate each function described in Section 17100 - Control Strategies. Demonstrate in detail how each function operates under a variety of operating scenarios. Test to verify the application of each general control strategy function to each specific control strategy or loop description.
2) Demonstrate the proper operation of the programming and configuration for each control strategy or loop description. Test each strategy or loop description on a sentence by sentence and function by function basis. Loops with similar or identical logic must each be tested individually.

3) Demonstrate the proper operation of all digital communication links and networks. Verify each digital communication I/O point.

4) Failure testing: In addition to demonstrating correct operation of all specified features, special effort shall be made to demonstrate how the system responds to and recovers from abnormal conditions including, but not limited to: equipment failure, operator error, communications subsystem error, communications failures, simulated/forced software lockups, power failure (both utility power and power to SCADA hardware), process equipment failure, and high system loading conditions.

c. Test forms:
   1) Include the fully revised and approved control strategy for the loop being tested.
   2) Identify the cause and effect as each I/O point is toggled through the simulator. Check boxes shall be provided to track proper and/or improper operation of the loop.
   3) Any deficiencies or operational changes shall be noted on the forms for correction and documentation:
      a) Include signature and date lines.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

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

   B. Installation supervision:
      1. Provide as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)
3.07 COMMISSIONING

A. District training:
   1. Complete District training as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Installation testing:
   1. General:
      a. The District reserves the right to test any specified function, whether or not explicitly stated in the test submittals.
      b. Failure testing:
         1) In addition to demonstrating correct operation of all specified features, demonstrate how the system reacts and recovers from abnormal conditions including, but not limited to:
            a) Equipment failure.
            b) Operator error.
            c) Communications sub-system error.
            d) Power failure.
            e) Process equipment failure.
            f) High system loading conditions.
      c. Conduct testing Monday through Friday during normal working hours for no more than 8 hours per day.
         1) Testing at other times requires approval of the Engineer.
   2. Sequencing:
      a. See additional requirements specified in the Sequencing article of Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
   3. Calibration:
      a. After installation but before starting other tests, calibrate and adjust all instruments, devices, valves, and systems, in conformance with the component manufacturer’s instructions and as specified in these Contract Documents.
      b. Components having adjustable features are to be set carefully for the specific conditions and applications of this installation. Test and verify that components and/or systems are within the specified limits of accuracy.
      c. Replace either individually or within a system, defective elements that cannot achieve proper calibration or accuracy.
      d. Calibration points:
         1) Calibrate each analog instrument at 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent of span, using test instruments with accuracies traceable to NIST.
      e. Field verify calibration of instruments that have been factory-calibrated to determine whether any of the calibrations are in need of adjustment.
f. Analyzer calibration:
   1) Calibrate and test each analyzer system as a workable system after installation. Follow the testing procedures directed by the manufacturers' technical representatives.

g. Complete instrument calibration sheets for every field instrument and analyzer.

h. Calibration tags:
   1) Attach a calibration and testing tag to each instrument, piece of equipment, or system.
   2) Sign the tag when calibration is complete.

4. Loop check/validation:
   a. Check all control loops under simulated operating conditions by causing a range of input signals at the primary control elements and observing appropriate responses of the respective control and monitoring elements, final control elements, and the graphic displays associated with the SCADA system. Issue commands from the SCADA system and verify proper responses of field devices. Use actual process inputs wherever available.
   b. Provide “end-to-end” tests:
      1) Test SCADA system inputs from field device to SCADA system operator workstations.
      2) Test SCADA system outputs from SCADA operator workstations to field devices and equipment.
      3) Observe and record responses at all intermediate devices.
      4) Test and record operator commands and signal readouts to each operator device where there is more than one operator interface point.
      5) For each signal, perform separate tests for SCADA computer screens, local operator interface (LOI) screens, and local control panels.
   c. Retest any loop following any necessary corrections.
   d. Apply simulated sensor inputs corresponding to 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent of span for networks that incorporate analog elements, and monitor the resulting outputs to verify compliance to accuracy tolerance requirements.
   e. Apply continuously variable up and down analog inputs to verify the proper operation and setting of discrete devices (signal trips, etc.).
   f. Apply provisional settings on controllers and alarm setpoints.
   g. Record all analog loop test data on test forms.
   h. Exercise each field device requiring an analog command signal, through the SCADA system. Vary, during the validation process, the output from the PLC SCADA system and measure the end device position, speed, etc. to confirm the proper operation of the device for the supplied analog signal. Manually set the output from the SCADA screen at 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent and measure the response at the final device and at any intermediate devices.
i. Exercise each field device providing a discrete input to the SCADA system in the field and observe the proper operation shall be observed at the operator workstation:

1) Test limit switches, set limits mechanically, and observe proper operation at the operator workstation.
2) Exercise starters, relay contacts, switch contacts, and observe proper operation.
3) Calibrate and test instruments supplying discrete inputs, and observe proper operation.

j. Test each device accepting a discrete output signal from the SCADA. Perform the appropriate operator action at the SCADA operator stations (including LOIs, if present) and confirm the proper operation of the field device:

1) Stroke valves through outputs from the SCADA system, and confirm proper directional operation. Confirm travel limits and any feedback signals to the SCADA system.
2) Exercise motors starters from the SCADA system and verify proper operation through direct field observation.
3) Exercise solenoids and other field devices from the SCADA system and verify proper operation through direct field observation.

k. Include in the test forms:

1) Analog input devices:
   a) Calibration range.
   b) Calibration data: Input, output, and error at each test value.
   c) Analog input associated PLC register address.
   d) Value in PLC register at each test point.
   e) Value displayed at each operator interface station (local operator interface displays and SCADA workstations).

2) Analog output devices:
   a) Calibration range.
   b) Test value at each test point.
   c) Analog output associated PLC register address.
   d) Control variable value at field device at each test point.
   e) Physical device response at each test point:
      (1) Response to be actual valve position, or motor speed, etc.
3) Discrete instrument input devices:
   a) Switch setting, contact action, and dead band.
   b) Valve position switches:
      (1) Response in the PLC as the valve is stroked from the PLC.
      (2) Field observed actual valve position, and valve indicator position as the valve is stroked from the PLC.
   c) Operator interface switches (control stations and other pilot devices) and associated response.
   d) Starter and drive auxiliary device contact response.
   e) Response of all other discrete inputs to the PLC.
4) Discrete output devices:
   a) Observed response of field device to the discrete output from the PLC.
   b) Observe the proper operation of Open, Close, Start, Stop, On, Off, etc.

5) Test equipment used and associated serial numbers.

C. Functional Testing:
   1. General:
      a. Commence Functional tests after completion of all loop check/validation tests:
         1) As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems, Sequencing and Scheduling article.
      b. Functional to demonstrate proper operation of all systems with process equipment operating over full operating ranges under conditions as closely resembling actual operating conditions as possible.
      c. Additional tests are specified in other Instrumentation and Control Sections.
      d. Follow approved detailed test procedures and check lists for Functional Test activities.
   2. Control logic operational validation:
      a. The purpose of control logic validation is to field test the operation of the complete control system, including all parts of the SCADA system, all control panels (including vendor control panels), all control circuits, all control stations, all monitored/controlled equipment, and final control elements.
      b. Demonstrate all control functionality shown on the P&IDs, control schematics, and other drawings, and specified in the loop descriptions, control strategies, Electrical Specifications, and Mechanical Equipment Specifications.
      c. Test in detail on a function-by-function and sentence-by-sentence basis.
      d. Thoroughly test all hardware and software functions:
         1) Including all hardwired and software control circuit interlocks and alarms.
      e. Test final control elements, controlled equipment, control panels, and ancillary equipment under startup, shut down, and steady-state operating conditions to verify all logic and control is achieved.
      f. Control logic validation tests to include, but not limited to: a repeat of all control logic tests from the FAT, modified and expanded to include all field instruments, control panels, circuits, and equipment.
3. **Loop tuning:**
   a. Optimally tune all electronic control stations and software control logic incorporating proportional, integral, or derivative control. Apply control signal disturbances at various process variable levels and adjusting the gain, reset, or rate settings as required to achieve proper response.
   b. Verify the transient stability of final control elements operating over the full range of operating conditions, by applying control signal disturbances, monitoring the amplitude and decay rate of control parameter oscillations and making necessary controller adjustments as required to eliminate excessive oscillatory amplitudes and decay rates. As a minimum, achieve 1/4-wave amplitude decay ratio damping (subsidence ratio of 4) under the full range of operating conditions.
   c. If excessive oscillations or system instability occur, as determined by the Engineer, continue tuning and parameter adjustments, or develop and implement any additional control algorithms needed to achieve satisfactory control loop operation.

4. **Functional validation sheets:**
   a. Document each Functional test on an approved test form.
   b. Document loop tuning with a report for each loop, including two-pen chart recordings showing the responses to step disturbance at a minimum of 3 setpoints or process rates approved by the Engineer. Show tuning parameters on the charts, along with time, date, and sign-off by Contractor and Engineer.
   c. Include on the form, functions which can be demonstrated on a loop-by-loop basis:
      1) Loop number and P&ID number.
      2) Control strategy, or reference to specification tested.
      3) Test procedures: Where applicable, use the FAT function-by-function, sentence-by-sentence loop test checklist forms modified to meet the requirements of the Functional test. Otherwise, create new forms.
   d. For functions that cannot be demonstrated on a loop-by-loop basis (such as overall plant power failure), include on the test form a listing of the specific steps and tests to be conducted. Include with each test description the following information:
      1) Specification page and paragraph of function demonstrated.
      2) Description of function and/or text from specification.
      3) Test procedures: use the FAT loop test checklist forms modified to meet the specific testing conditions of the Functional test.

5. **Functional certification:**
   a. Provide Manufacturer’s Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.
      1) Including all test forms with test data entered, submitted to the Engineer with a clear and unequivocal statement that all Functional test requirements have been satisfied.
D. Instrumentation Fine-Tuning:

1. After the Process Operational Period, test PCIS system for additional 60 days as specified in this Section to identify issues and make corrections, as needed.

2. General:
   a. The performance test is part of the Work that must be completed as a condition of substantial completion and final completion for the entire Project.
   b. The complete PLC control and SCADA system must run continuously for the duration of the performance test.
   c. Test and use the entire process control system under standard operating conditions.
   d. Exercise all system functions.
   e. Log failure, any system interruption and accompanying component, subsystem, or program failure including time of occurrence, duration of each failure, failure classification, and cause:
      1) Provide a competently trained technician or programmer on call for the Project Site during all normal working days and hours from the start of the performance test until final acceptance of the system.
         a) Response time to the Project Site: 24 hours or less, for a major failure.

3. SCADA system testing:
   a. Exercise each system function, e.g., status report, alarms, logs, and displays several times at a minimum, and in a manner that approximates "normal" system operation.
   b. Failure of the SCADA system during testing shall be considered as indicating that the programs and operating system do not meet the requirements of the specifications.
      1) Corrective action is required before restarting the performance test.
   c. Only those components, sub-systems, and systems covered in this Section and supplied under this Contract shall be considered for this acceptance test. Problems and failures of other systems shall not be considered as part of this test, except as they display the capabilities of this system to detect failures.

4. Failures:
   a. Classify failures as either major or minor:
      1) Minor failure:
         a) A small and non-critical component failure or software problem that can be corrected by the District's operators.
         b) Log this occurrence but this is not a reason for stopping the test and is not grounds for non-acceptance.
         c) Should the same or similar component failure occur repeatedly, this may be considered as grounds for non-acceptance.
         d) Failure of one printer or operator station is considered a minor failure providing all functions can be provided by backup equipment, i.e., alternate printers and operator station, and
repairs can be made and equipment returned to service within 3 working days.

2) Major failure:
   a) Considered to have occurred when a component, subsystem, software control, or program fault causes a halt in or improper operation of the system and/or when a technician's work is required to make a repair or to re-initiate operation of the system.
   b) Cause termination of the performance test.
   c) Start a new acceptance test when the causes of a major failure have been corrected.
   d) A failure is also considered major when failure of any control system that results in an overflow, underflow, overdose, or underdose condition occurs.

5. Technician report:
   a. Each time a technician is required to respond to a system malfunction, they must complete a report, which includes details concerning the nature of the complaint or malfunction and the resulting repair action required and taken.
   b. If a malfunction occurs which clears itself or which the operator on duty is able to correct, no report is required or logged as specified above.
   c. If a technician has performed work but no report is written, then a major failure is considered to have occurred.
   d. Each report shall be submitted within 24 hours to the Engineer and the District, or its representative.

3.08 FIELD QUALITY CONTROL (NOT USED)

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES

A. Example test forms:
   1. Example test forms are attached at the end of this Section. They may be used as a starting point for the development of Project-specific test forms for this Project.
   2. The example test forms are not intended to be complete or comprehensive. Edit and supplement the forms to meet the requirements for testing and test forms specified in this Section and other Contract Documents.

END OF SECTION
## FACTORY ACCEPTANCE TEST - CONTROL PANELS

### 1. GENERAL INSPECTION

#### A. Structural Inspection
- [ ] Verify Lifting Lugs Installed
- [ ] Verify enclosure has lock and lock is functional
- [ ] Confirm that seismic bracing components are provided per manufacturer’s installation instructions

#### B. Exterior Inspection
- [ ] Cabinet exterior is clean, scratch, and dent free
- [ ] Inspect externally for corrosion and damage
- [ ] Verify enclosure door opens and closes easily
- [ ] Verify enclosure has a 3-point latch
- [ ] Verify enclosure has a flange mounted disconnect (where voltages greater than 120 VAC enter the cabinet)
- [ ] Verify enclosure has the appropriate NEMA rating (1, 1G, 12, 3R, 4, 4X, etc.)
- [ ] Verify enclosure is the appropriate size (not grossly larger than design, and will still fit in the plant)

### Nameplates
- [ ] Cabinet has identification nameplate
- [ ] All door labels are straight, spelled correctly, and match the tagging defined in the Contract
- [ ] Cabinet has a nameplate that includes the following:
  - [ ] Power source(s)
  - [ ] Circuit ID(s)
  - [ ] Integrator’s Logo
  - [ ] Short Circuit KAIC ratings
- [ ] If labels are screwed to door, silicone was utilized to cover screw holes (Labels screwed to the door of a NEMA 4/4X panel technically violates the NEMA rating.)

### Door Devices
- [ ] All devices penetrating the outside of panel have gaskets, silicone or both
- [ ] All door devices are installed (HMI, Pilot Devices, etc.)
- [ ] Door mounted equipment is mounted straight and square
- [ ] All exterior or door mounted equipment present and accounted for, installed and securely fastened
- [ ] NEMA classification has not been violated due to penetrations
- [ ] Door mounted equipment has the same NEMA rating as the panel
- [ ] All door mounted equipment installed at the correct height
- [ ] All door mounted equipment installed in the correct positions and order (layout of door mounted equipment is grouped properly and in a logical manner)
- [ ] Doors with multiple penetrations have adequate bracing (if needed)
- [ ] Visually check condition of indicators, controllers and annunciators
- [ ] Check that pilot lights illuminate correctly
- [ ] Check the Push-To-Test function
- [ ] Ensure correct pilot light color

### Peripheral Devices
- [ ] Horn / Beacon is installed (where required)
- [ ] Silence and Reset pushbutton

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</table>
## FACTORY ACCEPTANCE TEST - CONTROL PANELS

1. GENERAL INSPECTION (continued)  
   C. Interior Inspection
   - Cabinet is cleaned of marks and dirt.
   - Inspect internally for corrosion and damage.
   - Back panel is clean of marks and dirt.
   - Interior of panel vacuumed and shall be free of all debris.
   - Check that the panel roof is clean and clear of foreign materials.
   - Bottom of panel has been cut out (where bottom entry is required), with angle iron welded around the bottom perimeter. Re-painting has been performed.
   - If internal light door limit switch is provided, ensure the light automatically turns "on" when the doors are open.
   - Intrusion alarms (where required).

### Interior Labeling

- All panel mounted equipment has identification labeling, by using either a Brothers or Phenolic type tags.
- Verify that door mounted components are mounted square and symmetrical.
- Verify that nameplates are straight, legible, and spelled correctly.
- All terminal blocks are identified/labeled with permanent labels including tight end blocks and caps.
- All wiring shrink labeled and or phased correctly to the specifications.
- All wire labels shrunk completely rotated and aligned alike for easy identification.
- All fuses and circuit breakers are labeled with ID and current rating.
- System Integrator’s label or labels installed on door.
- Panel manufacturer model/serial number tag is present.
- All required safety/warning tags installed and straight.
- Correct UL (typically UL 508) or cUL tag installed and registered and all other associated tags installed and straight (the UL tag might not be installed in the panel at the factory test. If the panel is modified due to changes during the factory test or a punch list generated from the factory test, the UL labeling would need to be re-applied. Some UL shops do not apply the UL label until the panel is released to be shipped.).

### Wireways

- Plastic wire way covers installed properly.
- Plastic wireways have no sharp edges.
- No wire Ties inside the wireways.
- No sharp edges on wire ties.
- Separation: White duct is used for DC voltages, Gray duct is used for AC voltages.
- Ensure wiring duct is not over-full, includes provision for 20% more wiring and the cover may easily be installed. Panduit recommends 50% duct fill, but 40% is a better practice.

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FACTORY ACCEPTANCE TEST - CONTROL PANELS

1. GENERAL INSPECTION (continued)

C. Interior Inspection (continued)

Wiring

- Visually check terminals and condition of internal wirings
- Verify that the control panel has been assembled and wired as designed
- Verify that all components are operational and perform the functions intended
- Verify that all components are sized appropriately for the application
- Verify that equipment control circuits function as intended
- Back of door wiring is labeled and neatly formed
- Back panel to door wiring has sufficient bending radius with spiral wrap
- Wire connection has been verified wired to correct points within the panel
- Individual wires have been given a pull test to verify a good terminal connection
- Wire and cable minimum bending radius have not been violated
- All equipment installed straight and square to back panel
- Wire colors are correct:
  - Black and White > AC hot and neutral, respectively
  - Red > AC control signals
  - Blue > DC power and control (Blue w/White stripe for DC ground)
  - Yellow > Foreign voltages (those still present when panel power is disconnected)
  - Green > AC equipment ground
  - Black > TSP (+)
  - White > TSP (-)
- Analog wiring shields are continuous (connected by a dedicated terminal block for such shields)
- Analog shield wires are grounded within the panel, where not otherwise grounded at the transmitter itself
- Discrete inputs are separately fused or protected by a circuit breaker on a “per loop” basis
- Intrinsic Safety Wiring
  - Ensure wiring associated with intrinsic safety circuits or intrinsic safety barriers is kept away from all other wiring by UL minimum distances or by a physical (grounded metal) barrier preventing non-intrinsically safe wiring from coming in contact with intrinsically safe circuits or wiring
- Verify all spare terminals are installed according to the percentage listed in the specifications

Grounding

- Equipped with “Blackburn” or other grounding type lug
- Lug is securely fastened to the panel structure
- Verify Grounding bar is installed
- Verify Isolated ground bar is installed
2. **POWER TEST**

A. **AC Power**

- AC Power is routed correctly within the panel, and is isolated from DC and network wiring.
- All fuses are installed and sized properly.
- All breakers are installed and sized properly.
- 24 VDC Power Supplies are functional.
- 24 VDC Power fail contacts are functional.
- 24 VDC power supplies are redundant, and have diode modules enabling the hot swap-over between supplies.
  - 24 VDC supplies are equipped with dry contact failure alarms, wired as PLC inputs to signal failure of any DC power supply. Such alarm inputs to the PLC have been tested as being functional.
- Dedicated receptacle is wired to receive a dedicated AC supply.
- Verify continuity for all DC commons, ground and AC neutrals.
- Verify that the CP temporary input power is connected correctly and is the correct voltage.
- Close the CP main circuit breaker(s).
- Verify that voltages at subsequent circuit breakers are correct.
- Close circuit breakers.
- Verify that power feeding interruptible and uninterruptible power supplies is correct.
- Turn on power supplies if they are not already on.
- Verify that voltages at distribution terminals are correct.
- Energize any remaining hardware such as the PLC.

B. **Uninterruptible Power Supply (UPS)**

- Mounted appropriately within the cabinet, on a dedicated shelf, or rear of a swing-out sub panel.
- Is equipped with maintenance bypass switch (or at least plug/receptacle means for bypassing the unit).
- Test all UPS alarms (on inverter, failure, battery failure etc.)
- Turn off the AC power supply and verify that the UPS will be switched on to supply the designated vital loads in the control panel.

3. **CONTROLS & AUXILIARY DEVICES TEST**

- Verify all interposing and auxiliary relays are functioning.
- Verify panel lights are functioning.

**Ventilation and Heating**

- If ventilation fans are fitted, check the fans operate correctly any associated air filters are clean and not blocked.
- Verify components are installed in the correct orientation for proper air flow.

4. **HARWARED INTERLOCK AND SAFETY TEST**

- Verify that hardwired interlocks through the control panel as shown on schematic drawings are functioning. For example, outlet high pressure switch interlock to a pump.
- Verify that all hardwired safety devices through the control panel is functioning. For example, the pull cord emergency stops of conveyors.
5. PLC TEST

A. Components
- PLC interior High Temperature alarm is installed, wired to the PLC, and is shown to be functional.
- Relays have transient suppression across their coils. This is particularly important for DC coil relays, where diodes in reverse polarity are often used.
- TVSS is installed across the main incoming 120 VAC.

**PLC and PLC Rack**
- Verify all cards are securely seated.
- Ensure clearance around PLC rack has been met, such that convective heat transfer is not impeded by devices erroneously mounted in the “no encroachment” area. Confirm with manufacturer clearance recommendations.

B. PLC I/O Test
- Furnish I/O test forms and test all the listed input and output points as follows:
  - Discrete Inputs: Simulate a field contact closure by “shorting” across the appropriate terminal blocks. Observe the transition between a logical “0” and “1” in the PLC software.
  - Discrete Outputs: Force the output bit to toggle between logical “0” and logical “1” using the PLC software. Measure contact resistance at the wired terminal blocks using a digital meter selected for the “ohms” setting.
  - Analog Inputs: Connect a signal generator to the appropriate terminal blocks. Tailor the connection depending on whether a 2-wire or 4-wire simulation is required. Modulate the 4-20mA signal. Observe the associated PLC internal memory register to transition between 0-65535 or if scaled in engineering units, between 0 and the maximum scaled engineering unit. The latter method is preferred.
  - Analog Outputs: Force the output register to a value between 0-65535 or 0-100%, if the scaling block can be manipulated. Observe the measured 4-20mA value increment and decrement using a digital ammeter.

C. Redundant Controllers (where required) Test
- Remove Communication cable from primary PLC to verify switching to backup PLC
- Remove Communication cable from backup PLC to verify switching back to primary PLC
- Remove Power cable from primary PLC to verify switching to backup PLC
- Remove Power cable from backup PLC to verify switching back to primary PLC

D. PLC Control Logic Verification
- The PLC control strategy is verified by following the Control Logic Verification Form based on the specifications. Each control strategy will be verified by simulating the process and checking the state or value of PLC outputs. The results of equipment status and alarms and process instrument values and trends shall also be verified on the Plant SCADA graphic screens stored in a temporary SCADA computer. Since all PLC input and output wiring has been verified and some field devices are not available during Factory Acceptance Testing, certain inputs will be simulated either by means of additional hardware and/or software as described below.
  - DI states are either simulated by hardwired switches or forced inputs using a programming terminal.
  - For example, when starters and drives are not provided as part of the contract, jumpers may be installed from the output call relays to the running confirmation inputs to simulate the running state of the motors.

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**PROJECT NAME:**

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**FACILITY NAME:**

**TESTED BY:**

**PROCESS AREA:**

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**NETWORK ID:**

**PAGE:**

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**SIGNATURE:**
5. PLC TEST (continued)
   D. PLC Control Logic Verification (continued)

   Typical Fault Logic
   - If the fault input is high and the disable (if applicable) for the fault is not high and the common disable (if applicable) is not high begin timing. If any of these conditions changes, stop timing and reset the timer. If the timer reaches its preset, activate the alarm output. If the fault alarm is a shutdown alarm stop the associated motor and latch the alarm so that it remains present even if the condition clears.
   - The fault condition must return to normal and the alarm must be reset for a latched alarm to clear.

   Typical Fail to Start Logic
   - If the motor is called to run (call output high) and no running feedback is received (running input is low) and the fail to start and common alarm disables (if applicable) are not high start timing. If any of these conditions changes, stop timing and reset the timer. If the timer reaches its preset, activate the alarm output, stop calling the motor and latch the alarm.

6. HMI OR OIT TEST

   HMI / OIT Functionality
   - Communication with PLC
   - Screen Layouts
   - Screen Navigation
   - Set Point Entry
   - Animation
   - Color Correctness (Green=Run, Red=Off, Amber=Alarm, or the agreed upon convention)
   - Alarms
   - Acknowledge and Reset
   - Security / Access Levels / Passwords

7. NETWORK COMMUNICATION TEST

   A. Network Components
   - Fiber optic cabling terminates in a patch panel
   - Media converters are installed and functional
   - Terminating resistors have been installed for trunk/tap topologies or where required
   - Wire and cable bending limitations have not been violated

   B. Networking Functions
   - Verify data transfer via the network to different PLCs as shown on the Network Block Diagrams
   - Verify network traffic rate and error margin is acceptable
### 8. FAT DOCUMENTATION AND RECORD

**Panel Documentation**

- As-built panel drawings showing actual panel construction and devices arrangement and c/w Bill of Material.
- Panel schematic and interconnection drawings.
- P&ID drawings and schematic drawings for the process area controlled by the panel that is to be tested.
- I/O list test forms of the process area to be tested.
- FAT procedure of the process area to be tested.
- Test record forms of the process area to be tested. Forms shall include area for signature of responsible test personnel.
- Hard copy of the PLC application program of the process area to be tested.
- Hard copy of the HMI/OIT graphic screens of the process area to be tested.

### 9. FAT TOOLS AND SOFTWARE

- Simulation software if required
- Digital volt meter Fluke 87
- Process meter Fluke 787
- Laptop computer with PLC application program
- Temporary SCADA computer with HMI software and applicable graphic screens
- Jumper wires

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April 2020 17950-22 10546B10
### INSTALLATION AND CERTIFICATION CHECKLIST DOCUMENTATION

<table>
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<th>SERVICE DESCRIPTION</th>
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A COPY OF LATEST ISSUE OF THE FOLLOWING DOCUMENTS ARE INCLUDED IN THIS INSTRUMENT INSTALLATION CERTIFICATION FILE:

- [ ] INSTRUMENT SPECIFICATION SHEETS (FOR ALL INSTRUMENTS IN THE LOOP)
- [ ] INSTRUMENT INSTALLATION DETAILS (FOR ALL INSTRUMENTS IN THE LOOP)
- [ ] INSTRUMENT LOOP WIRING DIAGRAMS
- [ ] INSTRUMENT INSTALLATION CERTIFICATION CHECKLIST
- [ ] SIZING CALCULATIONS
- [ ] INSTRUMENT INSTALLATION SCHEDULE (APPLICABLE PART)
- [ ] NAMEPLATE SCHEDULE (APPLICABLE PART)
- [ ] VENDOR LITERATURE CALIBRATION INFORMATION

INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS?  
No  Yes

REMARKS:

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CHECKED BY (COMPANY)  
ACCEPTED BY (COMPANY)

SIGNATURE  
SIGNATURE

DATE  
DATE

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### INSTALLATION AND CALIBRATION CHECKLIST

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CHECK BELOW, WHEN COMPLETED:

- [ ] BENCH CALIBRATED PER SPECIFICATION SHEET NO.
- [ ] VERIFIED PER P&ID NO.
- [ ] CORRESPONDS TO SPECIFICATION SHEET NO.
- [ ] WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO.
- [ ] INSTALLATION CORRECT PER DETAIL NO.
- [ ] ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED
- [ ] INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL
- [ ] ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS?  
No  Yes
## FIELD CALIBRATION CHECK

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NOTE: PERM is abbreviation for PERMISSIVE

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### SWITCHES INSTALLATION AND CALIBRATION CHECKLIST

REMKS: ____________________________________________________________

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### TRANSMITTER/CONTROLLER/INDICATOR

**INSTALLATION AND CALIBRATION CHECKLIST**

<table>
<thead>
<tr>
<th>INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS?</th>
<th>No</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>INSTRUMENT TYPE INDICATOR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TRANSMITTER</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CONTROLLER</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OTHER</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DESCRIPTION</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| INSTRUMENT TAG NO.                                           |    |
| SERVICE DESCRIPTION                                         |    |

**BENCH CALIBRATION CHECK**

<table>
<thead>
<tr>
<th>INPUT RANGE =</th>
<th>OUTPUT RANGE =</th>
</tr>
</thead>
<tbody>
<tr>
<td>HEAD CORRECTION =</td>
<td></td>
</tr>
<tr>
<td>CALIBRATED SPAN =</td>
<td></td>
</tr>
<tr>
<td>% CALIB SPAN</td>
<td>DESIRED VALUE</td>
</tr>
<tr>
<td>0</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

CHECK BELOW, WHEN COMPLETED:

- [ ] BENCH CALIBRATED PER SPECIFICATION SHEET NO.
- [ ] VERIFIED PER P&ID NO.
- [ ] CORRESPONDS TO SPECIFICATION SHEET NO.
- [ ] WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO.
- [ ] INSTALLATION CORRECT PER DETAIL NO.
- [ ] ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED
- [ ] INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL
- [ ] ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

**FIELD CALIBRATION CHECK**

<table>
<thead>
<tr>
<th>INPUT RANGE =</th>
<th>OUTPUT RANGE =</th>
</tr>
</thead>
<tbody>
<tr>
<td>% CALIB SPAN</td>
<td>DESIRED VALUE</td>
</tr>
<tr>
<td>0</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>
## TRANSMITTER/CONTROLLER/INDICATOR INSTALLATION AND CALIBRATION CHECKLIST

- DIRECT
- REVERSE
- ACTION VERIFIED AT 50% SPAN
- ACTION VERIFIED AT ____ SPAN

### CONTROLLER SETTINGS

<table>
<thead>
<tr>
<th>SETTING</th>
<th>GAIN</th>
<th>PB</th>
<th>RESET (INTEGRAL)</th>
<th>DERIV. (RATE)</th>
<th>HIGH LIMIT</th>
<th>LOW LIMIT</th>
<th>ELEV. ZERO</th>
<th>ZERO SUPP</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRE-TUNE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>POST-TUNE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### PRE-TUNE SETTINGS

<table>
<thead>
<tr>
<th>SETTING</th>
<th>GAIN</th>
<th>PB</th>
<th>RESET (REPEAT/MIN)</th>
<th>RESET (MIN/REPEAT)</th>
<th>DERIVATION (MINUTES)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FLOW</td>
<td>1.0</td>
<td>100</td>
<td>10</td>
<td>0.1</td>
<td>N/A</td>
</tr>
<tr>
<td>LEVEL</td>
<td>1.0</td>
<td>100</td>
<td>MIN.</td>
<td>MAX.</td>
<td>N/A</td>
</tr>
<tr>
<td>PRESSURE</td>
<td>2.0</td>
<td>50</td>
<td>2.0</td>
<td>0.5</td>
<td>N/A</td>
</tr>
<tr>
<td>TEMP.</td>
<td>4.0</td>
<td>25</td>
<td>0.1</td>
<td>10</td>
<td>OFF</td>
</tr>
</tbody>
</table>

### REMARKS

- 
- 
- 
- 
- 

CHECKED BY (COMPANY) ___________________________ ACCEPTED BY (COMPANY) ___________________________

SIGNATURE ___________________________ SIGNATURE ___________________________

DATE _______________ DATE _______________
<table>
<thead>
<tr>
<th>ANALYZERS INSTALLATION AND CALIBRATION CHECKLIST</th>
</tr>
</thead>
</table>

### Instrument Loop is Part of Equipment Start-Up/Shutdown Interlocks?
- [ ] No
- [x] Yes

### Instrument Details
- **Type of Instrument**
- **Instrument Tag No.**
- **Serial No.**

### Service Description

### Check Below, If True
- [ ] Bench Calibrated Per Specification Sheet No.
- [ ] Verified Per P&ID No.
- [ ] Corresponds to Specification Sheet No.
- [ ] Wiring Correct Per Instrument Loop Drawing No.
- [ ] Installation Correct Per Detail No.
- [ ] Accessories Are Present and Properly Installed
- [ ] Instrument Is Accessible for Maintenance or Removal
- [ ] Engraved Laminated Nameplate (No Spelling Errors) Permanently Installed

### Remarks

### Checked by (Company)
- **Signature**
- **Date**

### Accepted by (Company)
- **Signature**
- **Date**
CONTROL VALVES
INSTALLATION AND CALIBRATION CHECKLIST

INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS?
☐ No  ☐ Yes

☐ VALVE TAG NO. __________________________ SERIAL NO. __________________________
☐ TRANSDUCER TAG NO. __________________________ SERIAL NO. __________________________
☐ SOLENOID TAG NO. __________________________ SERIAL NO. __________________________
☐ VOLUME BOOSTER TAG NO. __________________________ SERIAL NO. __________________________
☐ POSITIONER __________________________ SERIAL NO. __________________________

SERVICE DESCRIPTION __________________________________________

TRANSDUCER CHECK

INPUT RANGE = ________________ OUTPUT RANGE = ________________
CALIBRATED SPAN = ________________ CALIBRATED SPAN = ________________

BENCH

<table>
<thead>
<tr>
<th>SPAN</th>
<th>DESIRED</th>
<th>ACTUAL</th>
<th>SPAN</th>
<th>EXPECTED</th>
<th>ACTUAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50%</td>
<td>50%</td>
<td>50%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

FIELD

<table>
<thead>
<tr>
<th>SPAN</th>
<th>DESIRED</th>
<th>ACTUAL</th>
<th>SPAN</th>
<th>EXPECTED</th>
<th>ACTUAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50%</td>
<td>50%</td>
<td>50%</td>
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<td></td>
</tr>
<tr>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CHECK BELOW, IF TRUE:
☐ BENCH CALIBRATED PER ABOVE __________________________________________
☐ VERIFIED PER P&ID NO. __________________________________________
☐ CORRESPONDS TO SPECIFICATION SHEET NO. __________________________________________
☐ VALVE SPECIFICATION NO. __________________________________________
☐ TRANSDUCER SPECIFICATION NO. __________________________________________
☐ SOLENOID SPECIFICATION NO. __________________________________________

☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. __________________________________________

☐ INSTALLATION CORRECT PER INSTRUMENT INSTALLATION DETAILS __________________________________________
☐ VALVE DETAIL NO. __________________________________________
☐ TRANSDUCER DETAIL NO. __________________________________________
☐ SOLENOID DETAIL NO. __________________________________________
## Control Valves

### Installation and Calibration Checklist

- **Accessories are present and properly installed**
- **Instrument is accessible for maintenance or removal**
- **Engraved laminated nameplate (no spelling errors) permanently installed**

### Valve Check

<table>
<thead>
<tr>
<th>Flow Check</th>
<th>Process flow direction through the valve is correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety Check</td>
<td>On Loss of air valve fails</td>
</tr>
<tr>
<td></td>
<td>Open [ ]</td>
</tr>
<tr>
<td></td>
<td>To vent [ ]</td>
</tr>
</tbody>
</table>

### Travel Check

<table>
<thead>
<tr>
<th>Full Open at</th>
<th>PSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Closed at</td>
<td>PSI</td>
</tr>
<tr>
<td>Measured Travel</td>
<td>Inches</td>
</tr>
</tbody>
</table>

### Seating Check

| On Bench [ ]                | Results                           |
| In-Line [ ]                 | Actuator bench set                |

### Positioner Check

- Valve full open at _________ PSI to positioner
- Valve full closed at _________ PSI to positioner

### Volume Booster Check

- By-pass valve (gain) adjusting screw backed out _________ turns from closed to ensure quick but stable operation (typically 1-1/2 to 2 turns)

### Remarks

- __________________________________________________________
- __________________________________________________________
- __________________________________________________________
- __________________________________________________________
- __________________________________________________________

### Checked by (Company)

- ____________________________

### Accepted by (Company)

- ____________________________

### Signature

- ____________________________

### Date

- ____________________________