



TUOLUMNE CITY SANITARY DISTRICT WASTEWATER TREATMENT PLANT UPGRADE

PROJECT NO. C-06-8247-210

CONSTRUCTION BIDDING DOCUMENTS VOLUME 2 - TECHNICAL SPECIFICATIONS

MARCH 2021



TUOLUMNE CITY SANITARY DISTRICT
WASTEWATER TREATMENT PLANT UPGRADE

PROJECT NO. C-06-8247-210

CONSTRUCTION BIDDING DOCUMENTS
VOLUME 2 - TECHNICAL SPECIFICATIONS

ISSUED FOR BIDS

MARCH 2021

18050 Box Factory Road, Tuolumne, CA 95379



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SECTION 01100
SUMMARY OF REQUIREMENTS

PART 1 GENERAL

1.01 LOCATION OF WORK

- A. The work is located at 18050 Box Factory Road, Tuolumne, CA 95379.

1.02 SCOPE OF WORK

- A. The work to be performed under this Contract shall consist of furnishing all equipment, materials, supplies, and manufactured articles, and furnishing all shipping and transportation and services, and performing all work or other operations required for the fulfillment of the Contract in strict accordance with the Contract Documents. The work shall be complete and all work, materials, and services not expressly indicated or called for in the Contract Documents which may be necessary for the complete and proper operation of the project shall be provided by the CONTRACTOR as though originally so indicated at no increase in cost to the DISTRICT.
- B. Work includes all appurtenant work for the complete installation of the facilities as shown on the Drawings, and other items of work that are required by the Contract Documents, Tuolumne City Sanitary District General Provisions, and these Project Specifications. In case of conflict, these Project Specifications shall take precedence.
- C. The CONTRACTOR is advised to inspect the site to observe actual working conditions.

1.03 PROJECT DESCRIPTION

- A. This project consists of shotcrete lagoon relining, RAS pump installation, SCADA system upgrades, and floating brush aerator installation as shown on the Drawings described herein. Alternate bid items include concrete paving and effluent line replacement.

1.04 WORK CONSTRAINTS

- A. Construction activities shall be scheduled in such a manner to limit construction disturbances and site disruption at each work site.
- B. The following constraints shall be followed during the course of construction.

1. The CONTRACTOR for this Project will be the PRIMARY CONTRACTOR responsible for coordinating all work schedules, all construction cleanup, and site safety for each working day of this Project.
2. Saw cutting of pavement shall not begin more than two weeks prior to construction within that work site.
3. CONTRACTOR shall contact USA prior to any excavation work.
4. Shutdowns for existing utilities shall be minimal. CONTRACTOR is responsible for providing bypass pumping or measures to ensure water, sewer, and electrical service is uninterrupted, unless otherwise approved.

1.05 CONNECTIONS TO EXISTING FACILITIES

- A. CONTRACTOR shall coordinate shutdowns or bypass pumping with DISTRICT staff, providing a minimum of 14 calendar days of prior notice. The CONTRACTOR shall schedule and coordinate the necessary shutdown or bypass of the existing facilities with the ENGINEER. The shutdown or bypass period shall be held to a minimum and the CONTRACTOR shall have all materials required for the work at the job site prior to requesting the action.
- B. As part of the requirements for submittal of progress schedules, CONTRACTOR is required to prepare and submit a written plan detailing the plan of operation, the materials, methods, schedule, equipment to be used, hours of operation, number of workers, and type of work to be conducted within the time period allowed for the disruption to wastewater treatment plant activities. The plan shall be submitted to the DISTRICT for approval 10 calendar days prior to planned work. Shutdowns or bypasses shall not proceed without the review and approval by the DISTRICT. No time extensions or damages will be considered for delays caused by failure of CONTRACTOR to plan, schedule and coordinate the work.
- C. CONTRACTOR shall make all excavations and furnish, install and maintain such shoring, bracing, and sheeting, and all materials necessary for all footings, forms and conduits.

1.06 CONSTRUCTION SEQUENCING

- 1.07 Construction sequencing information is provided in Table 1 below. Table 1 does not include sequencing requirements for all of the construction work. The information provided in Table 1 is a suggested work sequence. The CONTRACTOR may propose an alternative work sequence by obtaining approval from the ENGINEER prior to the start of construction. The CONTRACTOR is responsible for sequencing the work to provide complete and functional facilities with minimal disruptions to existing sewer service and treatment.

TABLE 1 – WORK SEQUENCE

Description	Requirements
A. Mobilization and Initial Tasks:	
	1) Prepare shop drawing submittal packages for ENGINEER review. 2) Prepare construction schedule and submit to ENGINEER for approval. 3) Complete preconstruction video recordings and photographs. 4) Prepare and submit permit packages for subsequent permit acquisition. 5) Prepare SWPPP, dust control, and dewatering plans (if applicable). 6) Plan and conduct field locating activities to determine if adjustments to pipeline alignment and/or structures are needed. 7) Prepare example public notice for OWNER approval. 8) Distribute public notices and obtain signatures verifying receipt of notices by the public. 9) Conduct pre-construction environmental surveys (if applicable), as required by the MMRP.
B. Construction:	
	1) Construct wastewater treatment plant upgrades. 2) Install connections to existing piping. 3) Conduct start-up testing for new facilities.
C. Demobilization and Contract Closeout:	
	1) Complete post construction video recordings and photographs.

1.08 SURVEY INFORMATION

- A. The CONTRACTOR shall provide construction staking where needed. The cost of construction staking shall be included in the CONTRACTOR'S bid price.
- B. The CONTRACTOR will be responsible for all lines, guides, and layout of all structures including but not limited to modifications to existing structures. From the information provided, the CONTRACTOR shall develop and make such additional surveys as are needed for construction, such as control lines, slope stakes, batter boards, and stakes for pipe locations and other working points, lines, and elevations. CONTRACTOR shall re-establish reference benchmarks and survey control monuments destroyed by his/her operations at no cost to the DISTRICT.

1.09 EXISTING UTILITIES

- A. The approximate location of known utilities is shown on the Drawings. CONTRACTOR shall verify the location of existing utilities in advance of construction to avoid project delays. Immediately notify the ENGINEER of any utilities not shown on the Drawings.
- B. Existing utilities and tie-ins are assumed to be accurate to within five feet (plus or minus) horizontal position. No additional compensation will be made for utilities and tie-ins within that accuracy.

- C. The CONTRACTOR, in conjunction with the affected utility companies, shall pothole and establish the horizontal and vertical location of all utilities shown on the Drawings and/or marked in the field. Utility location shall be accomplished at least ten working days in advance of the date of construction. Any discrepancies between the location of a utility found by the potholing operation than that shown on the Drawings shall be brought to the ENGINEER'S attention immediately. Potholing shall be required at the connection to existing facilities prior to the shop drawing and layout submittals.
- D. CONTRACTOR shall protect all underground utilities and other improvements which may be impaired during construction operations. CONTRACTOR shall take all possible precautions for the protection of unforeseen utility lines to provide for uninterrupted service and to provide such special protection as may be necessary.
- E. Prior to any excavation in the vicinity of any existing underground utilities, CONTRACTOR shall notify the respective authorities representing the Cities or agencies responsible for such facilities not less than three (3) days prior to excavation such that said Cities or agencies can be present during excavation work if they so desire.
- F. Nothing herein shall be deemed to require the DISTRICT to indicate the presence of existing service laterals or appurtenances when the presence of such utilities on the site of the construction project can be inferred from the presence of other visible facilities, such as buildings, meter and junction boxes, on or adjacent to the site of construction; provided, however, nothing herein shall relieve the DISTRICT from identifying water distribution mains, transmission mains or sewer trunk lines in the Drawings and Specifications.

1.10 EXISTING ELECTRICAL FACILITIES

- A. Existing overhead and underground electric facilities within or adjacent to the project shall be protected, relocated or removed as required by the Electric Company's Engineering Department.
- B. Costs for relocation and/or undergrounding the Electric Company's facilities as required and approved by the ENGINEER will be borne by the DISTRICT. Relocation or Installation of electric facilities shall conform to the requirements of the Electric Company's Engineering Department.
- C. CONTRACTOR shall contact the Electric Company's Electric Engineering Department to schedule and coordinate service requirements.
- D. Construction and installation of facilities covered in this project shall be separated from existing overhead and underground utilities:
 - 1. For existing overhead secondary lines, service lines and service drops, maintain a minimum working clearance of three (3) feet, or as required by the Electric Company Engineering Department.
 - 2. For existing overhead 12kV lines, maintain a minimum working clearance of ten (10) feet, or as required by the Electric Company Engineering Department and OSHA.

3. For existing overhead 69kV lines, maintain a minimum working clearance of eleven (11) feet, or as required by the Electric Company Engineering Department and OSHA.
 4. For underground perpendicular crossings, separate new facilities from existing with a minimum of 6 inches clear, or as required by the Electric Company Engineering Department.
 5. For underground parallel runs, separate new facilities from existing with a minimum of 12 inches clear, or as required by the Electric Company Engineering Department.
- E. Excavations and trenching shall maintain a 1:2 (vertical:horizontal) slope distance from any existing pole as determined by the depth of the trench. If trenching encroaches on this requirement, the Contractor shall contact the Electric Company's Engineering Department to brace any effected poles during the trenching process. The cost of any required pole bracing shall be borne by the CONTRACTOR.

1.11 MOBILIZATION AND DEMOBILIZATION

- A. Mobilization and demobilization includes all project preparatory/completion work and operations, including but not limited to; those necessary for the movement of personnel, equipment, supplies and incidentals to and from the project sites; the establishment of facilities necessary to conduct the specified work on the project; and setting up and rigging down. Additionally, this shall include all related work and operations which must be performed prior to and after completion of the project, such as, obtaining bonds, insurance policies, and permits, and filing the required reports at project completion and as required by the Contract Documents.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01110

WORK COVERED BY CONTRACT DOCUMENTS

PART 1 GENERAL

- A. This Section consists of a description of the items of work included in the base bid and additive bid items.

1.02 WORK INCLUDED AS BASE BID ITEMS

- A. The work under the base bid items of the Contract Documents consists of the following project elements. Work included under the base bid items assumes that additive bid items are not authorized by the OWNER.
 - 1. Mobilization/Demobilization – Work under this item shall include all labor, equipment, and materials required to mobilize to the project site and demobilize after the work is completed (maximum 5 percent of base bid amount).
 - 2. Storage Lagoon Shotcrete Relining – Work under this item shall include the preparation of the storage lagoon surface, demolition of existing structures and piping as shown in the Drawings, re-grading of the pond, installation of the liner, and installation of lagoon pipe and structure penetrations.
 - 3. Sludge Lagoon Aerator Installation – Work under this item shall include the purchase and installation of two floating brush aerators, as well as required support structures required, as shown in the Drawings.
 - 4. RAS Pump Installation – Work under this item shall consist of all work necessary for the construction of the RAS Pump Station adjacent to the existing integral clarifier. Work includes the construction of a pump pit; installation of three sludge pumps; installation of all piping and appurtenances within five feet, inclusive, of the structure; furnishing and installation of specified equipment not identified as separate bid items.
 - 5. Electrical Improvements - Work under this item includes the installation, activation and testing of all electrical wiring, conduit, lighting, SCADA upgrades, and specified control systems at the WWTP. Work also includes installation of all required cabinets, panels and junction boxes as specified; coordinating any needed shutdowns of service to the existing facilities; coordinating new service connections as needed; and connections to all new equipment and facilities as shown on the Drawings. Electrical requirements for additive bid items shall not be included under this bid item.

1.03 WORK INCLUDED AS ADDITIVE BID ITEMS

- A. Additive Bid Item A – Driveway Concrete Paving
 - 1. Work under this item shall include all grubbing, site preparation, grading, removal of existing curb, and concrete paving to extend the driveway as shown in the Drawings.

- B. Additive Bid Item B – Aeration Basin Concrete Paving
 - 1. Work under this item shall include all grubbing, site preparation, grading, removal of existing aggregate base, and concrete paving of the area surrounding the aeration basin as shown in the Drawings.
- C. Additive Bid Item C – Pump House Concrete Paving
 - 1. Work under this item shall include all grubbing, site preparation, grading, removal of existing aggregate base, and concrete paving of the area near the pump house as shown in the Drawings.
- D. Additive Bid Item D – Effluent Line Relocation
 - 1. Work under this item shall include all labor, materials, tools, equipment, and incidentals needed to deliver, unload, construct and test the effluent pipe in the location shown on the Drawings. Work shall also include the trench backfill to the specified compaction and the preparation or restoration of the finish grade. Work under this item shall include the required electrical improvements for the effluent line as shown in the Drawings. Work under this item shall include removal of LE line and capping existing pipe.

END OF SECTION

SECTION 01200
PROJECT MEETINGS

PART 1 GENERAL

1.01 GENERAL

- A. Project meetings will be held as often as deemed necessary by the CONSTRUCTION MANAGER. Meetings will normally be held weekly. CONTRACTOR'S Representatives shall attend.
- B. The purpose of the meetings will be to discuss project schedule, progress, coordination, submittals, and job-related problems.

END OF SECTION

SECTION 01280
MEASUREMENT AND PAYMENT

PART 1 GENERAL

1.01 METHOD OF MEASUREMENT

- A. All work completed under the contract is measured in U. S. standard measure.
 - 1. The DISTRICT measures and determines quantities of material furnished and work performed in accordance with these specifications and DISTRICT Standards.
 - 2. The methods of measurement and computations for determining quantities of material furnished and of work performed under the contract are methods generally recognized as conforming to good engineering practice.
- B. When the term "Estimated Quantity" is indicated in the Bid Schedule item designation:
 - 1. Accept the estimated quantity in the bid as the final quantity for which payment will be made, unless the ENGINEER revises the plan dimensions through an approved change order.
 - a. The ENGINEER adjusts the final quantity for payment by the amount of increase or decrease to the estimated quantity in the bid represented by authorized changes in dimensions.
 - 2. Request an adjustment to the final quantity for payment if an error is discovered in the estimated quantity in the bid.
 - a. Provide all computations, plots, and supporting documentation necessary for the ENGINEER to verify the error and determine the final quantity for payment.
 - b. All work associated with providing computations, plots, and supporting documentation is at no cost to the DISTRICT, except:
 - 1) Work required for providing computations, plots, and supporting documentation may be paid for as extra work when the final quantity differs from the estimated quantity by more than 10 percent.
- C. Lump Sum or Each:
 - 1. The DISTRICT measures the complete structure or structural unit, or other items of work specified in the bid to be measured by lump sum or each to include all necessary work, fittings, and accessories for a complete unit or system.
- D. Length:
 - 1. Items measured by the foot such as pipe culverts, striping, underdrains, etc. are measured parallel with the base, foundations and alignments of pipe upon which the structures or pipes are placed and shall include all necessary work, fittings, and accessories for a complete unit or system.
 - 2. The term "station" when used as a definition or term of measurement is 100 linear feet.
- E. Area:

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1. The DISTRICT uses horizontal longitudinal and plan (neat) transverse measurements unless otherwise specified.
- F. Volume:
1. The DISTRICT measures structures using plan (neat) dimensions or altered dimensions when approved by the ENGINEER to fit field conditions.
 2. The DISTRICT uses average end area for computing volumes of excavation.
 3. Materials specified to be measured by the cubic yard may be weighed and converted to cubic yard for payment purposes, when requested by the CONTRACTOR and approved by the ENGINEER in writing prior to procurement of materials.
 - a. Agree to the factors for conversion from weight measurement to volume as determined by the ENGINEER before using this method of measurement for computing pay quantities.
- G. Weight:
1. The term "ton" means 2000 pounds avoirdupois.
- H. Standard manufactured items such as fence, wire, plates, rolled shapes, pipe conduit, etc., identified by gauge, unit, weight, section dimensions, etc.
1. The DISTRICT uses nominal weights or dimensions and industry manufacturing tolerances unless otherwise specified.
- I. Plates and galvanized sheet used in the manufacture of corrugated metal pipe, metal plate pipe culverts and arches, and metal cribbing:
1. The DISTRICT measures thickness in fractions of inches.

1.02 WEIGHING REQUIREMENTS AND PROCEDURES

- A. Weigh all materials that are measured or proportioned by weight, or contract items measured by the ton, such as asphalt materials, on scales that have been approved, certified, and which meet specification requirements.
1. Obtain certified haul truck tares and place a legible identification mark on each truck.
 2. The DISTRICT may return any loads of material that appear to be deficient or questionable to be reweighed.

1.03 METHOD OF PAYMENT

- A. Payment will be made on the basis of the unit prices bid for the various items as called for on the Bid Form and included in the contract. The quantities given in the Bid Form are approximate only and are given as a basis for the comparison of bids, and the DISTRICT does not expressly or by implication agree that the actual amount of work will correspond therewith, but reserves the right to increase or decrease the amount of or any class or portion of the work or to omit portions of the work as may be deemed necessary or advisable by the DISTRICT ENGINEER.
- B. Payment for the various items of the Bid Schedule, as further specified herein, shall include all compensation to be received by the CONTRACTOR for furnishing all tools,

equipment, supplies, and manufactured articles, and for all labor, operations, and incidentals appurtenant to the items of work being described, as necessary to complete the various items of work as specified and shown on the drawings, including all appurtenances thereto, and including all costs of compliance with the regulations of public agencies having jurisdiction, including Safety and Health Requirements of the Division of Industrial Safety and the Occupational Safety and Health Administration of the U.S. Department of Labor (OSHA). No separate payment will be made for any item that is not specifically set forth in the Bid Schedule, and all costs therefore shall be included in the prices named in the Bid Schedule for the various appurtenant items of work.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01290
PAYMENT PROCEDURES

PART 1 GENERAL

1.01 METHOD OF PAYMENT

- A. Payment will be made on the basis of the prices bid for the various items as called for on the Bid Form and included in the contract as awarded in compliance with the bidding documents.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01310
PROGRESS SCHEDULES

PART 1 GENERAL

1.01 GENERAL

- A. The CONTRACTOR shall utilize the schedule method detailed in Paragraph 2.01, Construction Schedule (A).

1.02 PROCEDURES

- A. The CONTRACTOR shall provide with its schedule a procedural outline of the system shutdowns and proposed tie-in procedures, which shall be subject to the favorable review of the CONSTRUCTION MANAGER and the OWNER.

PART 2 SCHEDULES

2.01 CONSTRUCTION SCHEDULE (A)

- A. The schedule shall be submitted within ten (10) days of Notice to Proceed and favorably reviewed by the CONSTRUCTION MANAGER before the first partial payment can be made.

2.02 BASE SCHEDULE

- A. The CONTRACTOR shall submit the schedule based on either the bar chart method or the Critical Path Method (CPM). The schedule shall indicate preceding activity relationships and/or restraints where applicable and a controlling path shall be indicated. The schedule shall be time scaled and shall be drafted to show a continuous flow from left to right. The construction schedule shall clearly show the sequence of construction operations and specifically list:
 - 1. The start and completion dates of all work items.
 - 2. The dates of submittals, procurement, delivery, installation and completion of each major equipment and material requirement.
 - 3. Progress milestone events or other significant stages of completion.
 - 4. The lead time required for testing, inspection and other procedures required prior to acceptance of the work.
- B. Activities shall be no longer than ten (10) workdays, except for submittals and delivery items. If an activity takes longer, it shall be broken into appropriate segments of work for measurement of progress. This limitation may be waived, upon approval of the CONSTRUCTION MANAGER, for repetitious activities of longer durations for which progress can be easily monitored.

- C. The schedule shall be cost loaded with a breakdown of contract prices submitted by the CONTRACTOR.

2.03 REPORTS

- A. The following reports shall be submitted with the Base Schedule:
 - 1. Bar Chart: A manually generated report which lists each activity description, early start and finish dates, and all preceding and succeeding activities. Report shall indicate all critical activities. A report with the above information shall be provided with each monthly update in lieu of the report specified in Paragraph 5.01, Submittal Period.
 - 2. CPM Schedule: A CPM network report sorted by I-J or activity number which lists each activity description, early start and finish dates, preceding and succeeding activities and restraints, including lead/lag durations. The report shall show the critical path.
 - a. CPM network report sorted by total float.
 - b. CPM network report sorted by early start.

PART 3 CONSTRUCTION SCHEDULE B (NOT USED)

PART 4 WEATHER CONDITIONS

4.01 WEATHER CONDITIONS

- A. Seasonal weather conditions shall be considered in the planning and scheduling of work influenced by high or low ambient temperatures or precipitation to ensure the completion of the Work within the Contract Time. No time extensions will be granted for the CONTRACTOR'S failure to take into account such weather conditions for the location of the Work and for the period of time in which the Work is to be accomplished.
- B. "Weather Days Allowance" to be included at the end of the project schedule. When weather days are experienced, and are approved as such by the CONSTRUCTION MANAGER, the CONTRACTOR shall either:
 - 1. Increase the duration of the current critical activity(ies) by the number of weather days experienced, or
 - 2. Add a critical activity to the schedule to reflect the occurrence of the weather day(s).
- C. The duration of the weather day allowance activity shall be reduced as weather days are experienced and included in the schedule. Any remaining weather days in the weather day allowance activity at the completion of the project shall be considered as float and shall not be for the exclusive use or benefit of either the OWNER or CONTRACTOR.

PART 5 UPDATES

5.01 SUBMITTAL PERIOD

- A. The CONTRACTOR shall submit at monthly intervals a report of the actual construction progress. Each monthly report shall cover a period of approximately thirty (30) days ending around the 30th of each month. The monthly reports shall be submitted within ten (10) days of the end of the reporting period.

5.02 ALL MONTHLY UPDATES SHALL INCLUDE AS A MINIMUM:

- A. Tabulation reports for the following sorts:
 - 1. I-J [or Activity] Numbers
 - 2. Total Float
 - 3. Early Start
 - 4. Logic report of proceeding and succeeding activities with all restraints indicated (precedence schedules only)
- B. Narrative Report – The report shall show the activities or portions of activities completed during the reporting period. The report shall state the percentage of the work actually completed and schedule the remaining duration, and the progress along the critical path in terms of days ahead or behind the allowable dates as of the report date. Any changes made by the CONTRACTOR to the schedule, including I-J (or Activity) numbers and activity descriptions, shall be listed.

5.03 ON-SCHEDULE UPDATES

- A. If the project is proceeding on schedule, the monthly update report may consist of a marked-up copy of the graphical network diagram. This submittal shall clearly indicate the status of any minor shifts in sequence or schedule and the estimated completion date or percent complete of all activities currently in progress. The Contract completion date shall also be indicated. The CONTRACTOR shall submit a narrative report relating to status of construction, the schedule, and factors which may affect the remainder of the schedule.

5.04 DELAYED SCHEDULE UPDATES

- A. If, in the discretion of the CONSTRUCTION MANAGER, the project is believed to be behind schedule, the monthly report shall include a revised network diagram and/or mathematical analysis showing the CONTRACTOR'S proposed revised schedule. The schedule shall be revised under the conditions defined in Paragraph 5.06, Schedule Revisions. An analysis of the effect that the delay has on progress along other paths shall also be included in the report. The CONTRACTOR shall also submit a narrative report with each updated analysis which shall include but not be limited to a description of current and anticipated problem areas, delaying factors and their impact, and an explanation of corrective actions taken or proposed.

5.05 SCHEDULE REVIEW

- A. Once each month, on a date mutually agreed upon, but no later than seven (7) working days after the submittal of the monthly update specified herein, a jobsite meeting will be held to review the Construction Schedule, job progress and the monthly update, or the CONSTRUCTION MANAGER will provide written comments on the monthly update.

5.06 SCHEDULE REVISIONS

- A. The conditions under which the CONSTRUCTION MANAGER may require revisions of the Construction Schedule include the following:
 - 1. When delay in completion of any work item or sequence of work items results in an estimated extension of project completion by either twenty (20) working days or by five percent (5%) of the remaining duration of time to complete the Contract, whichever is less.
 - 2. When delays in submittals or deliveries make replanning or rescheduling of the work necessary.
 - 3. When the schedule does not represent actual prosecution and progress of the work.
 - 4. When any change to the sequence of activities, the completion date for major portions of the work, or changes occur which affect the critical path.
 - 5. When Contract modification necessitates schedule revision.

PART 6 TIME IMPACT ANALYSES

6.01 TIME IMPACT ANALYSES

- A. When Change Orders are initiated, delays are experienced, or the CONTRACTOR desires to revise the schedule logic, the CONTRACTOR shall submit to the CONSTRUCTION MANAGER a written Time Impact Analysis illustrating the influence of each change, delay, or CONTRACTOR request on the current Contract Schedule completion date.

6.02 CONSTRUCTION SCHEDULE (A) – ANALYSIS

- A. Each Time Impact Analysis shall include an analysis demonstrating how the CONTRACTOR proposes to incorporate the change order, delay, or CONTRACTOR request into the Schedule.
- B. The analysis shall demonstrate the time impact based on the date of occurrence of the change, delay or revision; the status of construction at that point in time; and the impact of all affected activities.

6.03 CONSTRUCTION SCHEDULE (B) – ANALYSIS (NOT USED)

6.04 ACTIVITY TIME DELAYS

- A. Activity time delays will not automatically mean that an extension of Contract Time is warranted or due the CONTRACTOR.
1. It is possible that a strike or contract modification will not affect existing critical activities or cause non-critical activities to become critical, i.e., a strike or modification may result in only absorbing a part of the available total float that may exist within an activity chain of the network, thereby not causing any effect on the Contract completion date or time.
 2. The CONTRACTOR acknowledges and agrees that mitigation for delays due to changes, differing site conditions, and other causes will require revision of preferential sequences of the Work before proposing an updated schedule which supports a delay to the Project as a whole. When a delay to the Project as a whole can be avoided by revising preferential sequencing, and the CONTRACTOR chooses not to implement the revisions, the CONTRACTOR will be entitled to a time extension but is not entitled to compensation for indirect overhead.
 3. Float or slack shall not be for the exclusive use or benefit of the OWNER or the CONTRACTOR. Extensions of time for performance will be granted only to the extent that the equitable time adjustments for the activity or activities affected exceeds the total float along the activity chain involved at the time the change was ordered or the delay occurred.
 4. The definitions of "non-critical activities" and "total float" shall be as provided in the Associated General Contractors of America book "CPM in Construction, A Manual for General Contractors."

6.05 TIME IMPACT

- A. Time Impact Analyses shall be submitted in triplicate and within fifteen (15) days after a delay occurs or with the CONTRACTOR'S cost proposal in response to a notice of change from the CONSTRUCTION MANAGER. In cases where the CONTRACTOR does not submit a Time Impact Analysis for a specific Change Order, delay, or CONTRACTOR request within the specified period of time, then it is mutually agreed that the particular change order, delay, or CONTRACTOR request has no time impact on the Contract completion date and no time extension is required.
1. Approval or rejection of Time Impact Analyses by the CONSTRUCTION MANAGER and the OWNER will be made within fifteen (15) days after receipt of the Time Impact Analysis unless subsequent meetings and negotiations are necessary.
 2. Upon approval, a copy of the Time Impact Analysis signed by the CONSTRUCTION MANAGER and OWNER will be returned to the CONTRACTOR.
 3. Upon mutual agreement by both parties, schedule revisions illustrating the influence of change orders, delays, and/or CONTRACTOR requests will be incorporated into the next schedule update.

PART 7 WEEKLY ACTIVITIES PLAN

7.01 WEEKLY ACTIVITIES PLAN

- A. On the last working day of every week the CONTRACTOR shall submit to the CONSTRUCTION MANAGER the CONTRACTOR'S Plan of Activities for the following three weeks. The Plan of Activities shall describe the activity and location of the activity and include the activity's I-J or Activity number as provided in the Construction Schedule.

END OF SECTION

SECTION 01320

CONSTRUCTION PROGRESS DOCUMENTATION

PART 1 GENERAL

1.01 SUMMARY

- A. This Section specifies the procedures for construction progress documentation for planning and management of construction activities. The documents listed in this section provide a basis for determining the progress status of the project relative to the completion time, specific dates, and for determining the acceptability of the CONTRACTOR'S progress payment estimates.

1.02 CONFORMANCE WITH GENERAL PROVISIONS

- A. In addition to this section, the CONTRACTOR shall comply with all requirements of the DISTRICT General Requirements.

PART 2 PRODUCTS

2.01 CONSTRUCTION SCHEDULE

- A. The CONTRACTOR shall provide a construction schedule prepared by the critical path method (CPM) of analysis. The critical path schedule shall be prepared from estimates of the required duration and sequence for each item of work and task to be performed. A general guide for preparing such a schedule is contained in "The Use of CPM in Construction, a Manual for Contractors," published by the Associated General Contractors of America. No progress payments will be made until the ENGINEER has accepted the CONTRACTOR'S construction schedule.
- B. The CONTRACTOR shall provide a schedule of the overall project at the preconstruction meeting.
- C. Tabulation and analysis of the work schedule shall be performed by a computer software program. The software program shall meet these minimum requirements:
 - 1. Latest version of software
 - a. Microsoft © Project
 - b. Oracle © Primavera
 - c. or approved equal
 - 2. Capability to produce tabular reports
 - 3. Capability to plot the construction schedule on an 11-inch x 17-inch sheet
 - a. The CONTRACTOR shall provide an electronic copy in *.MPP format and *.PDF format (11-inch x 17-inch). Each electronic file shall bear a new file name, preferably a sequential number system, so that previous submittals may be distinguished from each other.

- D. The schedule shall depict all significant construction activities, and shall include all activities with:
 - 1. A value greater than one percent (1.0 percent) of the total contract amount or \$25,000 per task, whichever is less
 - 2. A duration NO longer than 15 days; exceptions include activities comprising only of fabrication and delivery
 - 3. Submittal / Fabrication / Delivery periods which total an aggregate greater than three (3) months
 - 4. Cost loaded with a breakdown of contract prices submitted by the CONTRACTOR
 - 5. Resource loaded including all equipment necessary for each task. The dependencies between activities shall be indicated so that it may be established what effect the progress of any one activity has on the schedule. The critical path shall be clearly indicated. Activities that exceed these limits shall be divided into more detailed components. The scheduled duration of each activity shall be based on the work being performed during the normal 40-hour workweek with allowances made for DISTRICT non-working days and normal weather conditions.
- E. Any contingency within the schedule (i.e., a difference in the time between the project's early completion and required contract completion date) and float in the schedule will belong to the project and not to any of the parties to the contract.
- F. In addition to the overall schedule, a three-week bar chart schedule shall be provided.
- G. The three-week bar chart schedule shall be provided weekly after acceptance of the overall schedule. The format shall be one week of history and two weeks of look ahead. It shall be on a work crew level but with schedule activity numbers clearly indicated. It shall be directly produced from the approved project CPM schedule database not independently from some other data.
- H. The CONTRACTOR shall not be permitted to sequester shared float through such strategies as extending duration estimates to consume available float time, extensive crew/resource sequestering, etc.

2.02 SCHEDULE OF VALUES

- A. The CONTRACTOR shall submit a detailed schedule of values for use in preparing pay estimates and in evaluating changes. Each activity in the schedule of values shall correlate to an activity in the construction schedule. The data in these reports shall serve as the basis for processing the CONTRACTOR'S progress payment requests. The CONTRACTOR shall be responsible for the adequacy of the schedule and for managing all construction activities including, but not limited to those of the subcontractors and suppliers. The schedule of values shall be submitted in accordance with Section 01330 Submittal Procedures.

2.03 CONSTRUCTION PHOTOGRAPHS & VIDEO RECORDING

- A. The color photographs and color audio-video recordings are intended for use as indisputable evidence in ascertaining the extent of any damage which may occur as a result of the CONTRACTOR'S operations and are for the protection of the public, the

CONTRACTOR and the DISTRICT. These documents will be a means of determining whether and to what extent damage, resulting from the CONTRACTOR'S operations, occurred during the execution of the Contract work. All original pre-and post-construction video recording and photograph files shall be delivered to the DISTRICT and shall become the property of the DISTRICT.

1. PHOTOGRAPHS

a. Photograph documents shall meet the following requirements:

- 1) Color digital photographs with a minimum resolution of 2304 x 1728 pixels (3.0 Megapixels)
- 2) Time & Date stamp on the photograph of when the image was taken
- 3) Location where the photograph was taken

2. VIDEO

a. Video recording documents shall meet the following requirements:

- 1) Video with audio shall be recorded to a digital storage device (DVD, flash drive, etc.)
- 2) The recorded file format shall be avi or mp4
- 3) The video shall have a minimum resolution of 1920x1080.
- 4) The DVD case and disc labels shall list the date, name of contract, and the location where the images were recorded
- 5) The audio portion of the video recording shall narrate the progression through the site
- 6) All video recordings must display date and time of recording, and location.

b. Each recording shall be submitted to the ENGINEER in accordance with Section 01330 Submittal Procedures.

PART 3 EXECUTION

3.01 CONSTRUCTION SCHEDULE

- A. CONTRACTOR shall complete a construction schedule conforming to requirements of these specifications and representing in detail all planned procurement and on-site construction activities. A computer data compact disc (CD) of the project schedule shall be provided to the Construction Manager to facilitate analysis. In addition to the CD, one (1) 11-inch x 17-inch reproducible paper copy of the construction schedule shall be submitted at the preconstruction meeting.
- B. Within ten (10) business days after receipt of the submittal, the ENGINEER shall review the submitted schedule and return one copy of the marked-up original to the CONTRACTOR. If the ENGINEER finds that the submitted schedule does not comply with specified requirements, the corrective revisions will be noted on the submitted copy returned to the CONTRACTOR for corrections and resubmitted in accordance with Section 01330 Submittal Procedures.
- C. Percent complete is based on each activity of COMPLETED work that has been assigned a value on the detailed schedule of values. The agreed-upon percentage complete shall be the basis for determining the monthly progress payments.

3.02 SCHEDULE REVISIONS

- A. Revisions to the items which are on the critical path as shown on the accepted CPM schedule logic may be made ONLY with written approval of the ENGINEER. Changes in timing for activities which are not on the critical path may be modified within the available period of the activities' specific available float but not in a manner which will place them on the critical path.
- B. Proposed and approved contract change orders shall be added to the approved schedule in a manner which conforms to their correct relationship to other project activities and a copy of the resultant schedule provided to the ENGINEER. Change orders shall not be approved until the schedule has been modified to show their effect. The schedule impact of any proposed change shall be calculated and submitted to the ENGINEER within ten (10) days of receipt by the CONTRACTOR of a request for proposal.
- C. The CPM schedule shall be updated if activities fall behind schedule or to reflect proposed and approved change orders or inclement weather delays.

3.03 CONSTRUCTION PHOTOGRAPHS & VIDEO RECORDING

- A. After the Contract is awarded but before mobilization to the site, the CONTRACTOR shall make a thorough examination of all the existing structures, vegetation, utilities, and general condition of the worksite and shall record all existing site conditions using photographs and video.
- B. After the completion of the overall project, post-construction video and photograph documents shall be done. A copy of all post-construction recorded documents shall be provided to the ENGINEER. The ENGINEER will ascertain the extent of damage, if any, and will determine whether existing improvements, damaged or removed during construction, have been returned to specified or original condition. Final payment shall not be made until the ENGINEER has determined that the construction site meets or exceeds the specified or original condition.
- C. VIDEO
 - 1. The CONTRACTOR shall provide pre-construction video recording of the entire project, including staging, parking, and storage areas to the ENGINEER for each site prior to performing any work on the site.
 - a. For projects within the public right-of-way, provide recording along the alignment in both directions
 - b. For projects at a specific site, provide recording along the perimeter of the site in both directions as well as any other pertinent site features
 - 2. No construction shall start until the preconstruction video recording has been completed and approved by the ENGINEER.
 - 3. After completion of construction, video recording shall be taken from the same points in both directions as the preconstruction recording within seven (7) calendar days after the acceptance of the project by the DISTRICT. Final payment will not be made to the CONTRACTOR until the DISTRICT receives copies of the video recordings which reflect the final conditions.

D. CONSTRUCTION PHOTOGRAPHY

1. The CONTRACTOR shall provide preconstruction photographs to the ENGINEER for each site prior to performing any work on the site.
2. Photographs shall be provided during construction to show all utility crossings, excavations for pipe, installation of pipe, removal and restoration of surface features such as trees, shrubs, rock retaining structures, fences, drainage canals and any items of special interest upon the request of the ENGINEER.
3. Provide photographs taken on cutoff date for each scheduled application for payment.

END OF SECTION

SECTION 01330

SUBMITTAL PROCEDURES

PART 1 GENERAL

1.01 GENERAL

- A. Submittals covered by these requirements include manufacturers' information, shop drawings, test procedures, test results, samples, requests for substitutions, and miscellaneous work-related submittals. The CONTRACTOR shall furnish all drawings, specifications, descriptive data, certificates, samples, tests, methods, schedules, and manufacturer's installation and other instructions as specifically required in the Contract Documents to demonstrate fully that the materials and equipment to be furnished and the methods of work comply with the provisions and intent of the Contract Documents.

1.02 CONTRACTOR'S RESPONSIBILITIES

- A. The CONTRACTOR shall be responsible for the accuracy and completeness of the information contained in each submittal and shall assure that the material, equipment or method of work shall be as described in the submittal. The CONTRACTOR shall verify that all features of all products conform to the specified requirements. Submittal documents shall be clearly edited to indicate only those items, models, or series of equipment, which are being submitted for review. All extraneous materials shall be crossed out or otherwise obliterated. The CONTRACTOR shall ensure that there is no conflict with other submittals and notify the ENGINEER in each case where his submittal may affect the work of another contractor or the DISTRICT. The CONTRACTOR shall coordinate submittals among his subcontractors and suppliers including those submittals complying with unit responsibility requirements specified in applicable technical sections.
- B. The CONTRACTOR shall coordinate submittals with the work so that work will not be delayed. The CONTRACTOR shall coordinate and schedule different categories of submittals, so that one will not be delayed for lack of coordination with another. No extension of time will be allowed because of failure to properly schedule submittals. The CONTRACTOR shall not proceed with work related to a submittal until the submittal process is complete.
- C. The CONTRACTOR shall certify on each submittal document that he has reviewed the submittal, verified field conditions, and complied with the Contract Documents.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 TRANSMITTAL PROCEDURE

- A. Unless otherwise specified, submittals regarding material and equipment shall be accompanied by Transmittal Form. A separate form shall be used for each specific item, class of material, equipment, and items specified in separate, discrete sections, for which the submittal is required. Submittal documents common to more than one piece of equipment shall be identified with all the appropriate equipment numbers. Submittals for various items shall be made with a single form when the items taken together constitute a manufacturer's package or are so functionally related that expediency indicates checking or review of the group or package as a whole.
- B. If the CONTRACTOR proposes to provide material, equipment, or method of work which deviates from the project requirements, he shall indicate so under "deviations" on the transmittal form accompanying the submittal copies.

3.02 SUBMITTAL REVIEW PROCEDURE

- A. Review shall not extend to means, methods, techniques, sequences or procedures of construction. Verifying quantities, dimensions, weights or gages, or fabrication processes (except where specifically indicated or required by the project) or to safety precautions or programs incident thereto. Review of a separate item, as such, will not indicate approval of the assembly in which the item functions.
- B. Five copies, unless otherwise specified during the preconstruction meeting, of all submittals required shall be furnished to the ENGINEER for review. The ENGINEER shall review the submittal and return two copies of the marked-up original within 10 working days after receipt of a submittal for review and comment, unless otherwise specified. All shop drawings and layout drawings submittals shall be submitted a minimum of 20 working days before approved submittal drawings will be required for the work.
- C. Submittals which do not have all the information required to be submitted, including deviations, are not acceptable and will be returned without review.

3.03 EFFECT OF REVIEW OF CONTRACTOR'S SUBMITTALS

- A. Review of Contract Drawings, methods of work, or information regarding materials or equipment the CONTRACTOR proposes to provide, shall not relieve the CONTRACTOR of his responsibility for errors therein and shall not be regarded as an assumption of risks or liability by the ENGINEER or the DISTRICT, or by any employee thereof, and the CONTRACTOR shall have no claim under the Contract on account of the failure, or partial failure, of the method of work, material, or equipment so reviewed.
- B. The Work covered by a submittal may be commenced only after the ENGINEER has reviewed the pertinent submittals and returned copies to the CONTRACTOR marked

either "No Exceptions Taken" or "Make Corrections Noted." Corrections indicated on submittals shall be considered as changes necessary to meet the requirements of the Contract Documents. Review of submittals by the ENGINEER shall not be construed as relieving the CONTRACTOR of his/her responsibilities under this Contract.

END OF SECTION

SECTION 01340

SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES

PART 1 GENERAL

1.01 CONTRACTOR'S RESPONSIBILITIES

- A. The CONTRACTOR shall submit, at their own expense, submittals and details of structural and reinforcing steel, mechanical, electrical, and instrumentation and control equipment, material, electrical controls, architectural fabrications, pipe, civil work materials, pipe joints, special pipe sections, and other appurtenances as required in technical specifications, as shown on the drawings.
- B. All submittals and supporting data, catalogs, schedules, etc., shall be submitted as the instruments of the CONTRACTOR, who shall be responsible for their accuracy and completeness and coordination. Such responsibility shall not be delegated in whole or part to subcontractors or suppliers. These submittals may be prepared by the CONTRACTOR, subcontractors, or suppliers, but the CONTRACTOR shall ascertain that submittals meet all of the requirements of the Contract Documents, while conforming to structural, space, and access conditions at the point of installation. Designation of work "by others," if shown in submittals, shall mean that the work will be the responsibility of the CONTRACTOR rather than the subcontractor or supplier who prepared the submittals. The CONTRACTOR shall insure that there is no conflict with other submittals and notify the CONSTRUCTION MANAGER in each case where their submittal may affect the work of another CONTRACTOR or the OWNER. The CONTRACTOR shall insure coordination of submittals among the related crafts and subcontractors.
- C. Submittals shall be prepared in such form that data can be identified with the applicable Specification paragraph. The data shall clearly demonstrate compliance with the Contract Plans and Specifications and shall relate to the specific equipment to be furnished. Where manufacturer's standard drawings are employed, they shall be marked clearly to show what portion of the data is applicable to this project.

PART 2 TRANSMITTAL PROCEDURES

2.01 TRANSMITTAL FORM

- A. A separate transmittal form shall be used for each specific item, class of material, equipment, and items specified in separate, discrete sections, for which the submittal is required. Submittal documents common to more than one piece of equipment shall be identified with all the appropriate equipment numbers. Submittals for various items shall be made with a single form when the items taken together constitute a manufacturer's package or are so functionally related that expediency indicates

checking or review of the group or package as a whole. The specification section to which the submittal is related shall be indicated on the transmittal form.

- B. A unique number, sequentially assigned, shall be noted on the transmittal form accompanying each item submitted. Original submittal numbers shall have the following format: "XXX"; where "XXX" is the sequential number assigned by the CONTRACTOR. Resubmittals shall have the following format: "XXX-Y"; where "XXX" is the originally assigned submittal number and "Y" is a sequential letter assigned for resubmittals, i.e., 1, 2, or 3 being the 1st, 2nd, and 3rd resubmittals, respectively. Submittal 25-2, for example, is the second resubmittal of submittal 25.

2.02 DEVIATIONS FROM THE CONTRACT

- A. If the submittals show any deviations from the Contract requirements, the CONTRACTOR shall submit with the submittal submission a separate written description of such deviations and the reasons therefore. If the OWNER accepts such deviation, the OWNER shall issue an appropriate Contract Change Order, except that, if the deviation is minor, or does not involve a change in price or in time of performance, a Change Order need not be issued. If any deviations from the Contract requirements are not noted on the submittal, the review of the shop drawing shall not constitute acceptance of such deviations.

2.03 SUBMITTAL COMPLETENESS

- A. The CONTRACTOR shall check all submittals before submitting them to the CONSTRUCTION MANAGER and shall certify on the transmittal letter and on each shop drawing that they have been checked, are in compliance with the Plans and Specifications, and all deviations from the Contract requirements are noted.
- B. If the CONTRACTOR submits an incomplete submittal, the submittal will be returned to the CONTRACTOR without review. A complete submittal shall contain sufficient data to demonstrate that the items comply with the Specifications, shall meet the minimum requirements for submissions cited in the technical specifications, shall include materials and equipment data and seismic anchorage certifications where required, and shall include any necessary revisions required for equipment other than first named.
- C. It is considered reasonable that the CONTRACTOR shall make a complete and acceptable submittal to the CONSTRUCTION MANAGER at least by the second submission of data. The OWNER reserves the right to deduct monies from payments due the CONTRACTOR to cover additional costs of review beyond the second submission.

2.04 SUBMITTAL PERIOD

- A. All submittals shall be completed within sixty (60) calendar days after Notice to Proceed by the OWNER, unless the CONSTRUCTION MANAGER accepts an alternate schedule for submission of submittals proposed by the CONTRACTOR.

PART 3 REVIEW

3.01 REVIEW PROCEDURE

- A. Submittals shall be submitted to the CONSTRUCTION MANAGER for review and returned within twenty (20) working days after receipt. Review of submittals by the DESIGN CONSULTANT has as its primary objective the completion for the OWNER of a project in full conformance with the Contract Plans and Specifications, unmarred by field corrections, and within the time provided. In addition to this primary objective, submittal review as a secondary objective will assist the CONTRACTOR in their procurement of equipment that will meet all requirements of the project Plans and Specifications, will fit the structures detailed on the Plans, will be completed with respect to piping, electrical, and control connections, will have the proper functional characteristics, and will become an integral part of a complete operating facility.
- B. After review by the DESIGN CONSULTANT of each of the CONTRACTOR'S submissions, the submittal will be returned to the CONTRACTOR with actions defined as follows:
 - 1. **NO EXCEPTIONS NOTED (RESUBMITTAL NOT REQUIRED)** – Accepted subject to its compatibility with future submissions and additional partial submissions for portions of the work not covered in this submission. Does not constitute approval or deletion of specified or required items not shown in the partial submission.
 - 2. **MAKE CORRECTIONS NOTED (RESUBMITTAL NOT REQUIRED)** – Same as above (No. 1), except that minor corrections as noted shall be made by the CONTRACTOR.
 - 3. **MAKE CORRECTIONS NOTED (RESUBMIT)** – Rejected because of major inconsistencies or errors, which shall be resolved or corrected by the CONTRACTOR prior to subsequent review by the DESIGN CONSULTANT.
 - 4. **NOT ACCEPTABLE (RESUBMIT)** – Submitted material does not conform to Plans and Specifications in major respect, i.e.: wrong size, model, capacity, or material.
- C. Items 1 and 2 above (no resubmittal required) are considered "favorable review." Items 3 and 4 above (correction and resubmittal required) are considered "unfavorable review."
- D. It shall be the CONTRACTOR'S responsibility to copy and/or conform reviewed submittals in sufficient numbers for its files, subcontractors and vendors.
- E. Submittals requiring reviews beyond the second submission shall be performed by the OWNER'S Representative with all costs being reimbursed to the OWNER by the CONTRACTOR.

PART 4 EFFECT OF REVIEW

4.01 EFFECT OF REVIEW OF CONTRACTOR'S SUBMITTALS

- A. The DESIGN CONSULTANT'S favorable review of submittals shall be obtained prior to the fabrication, delivery, and construction of items requiring submittal review.
- B. Favorable review of submittals does not constitute a Change Order to the Contract requirements.
- C. The favorable review of all submittals by the DESIGN CONSULTANT shall be for general conformance with the Contract requirements and shall in no way relieve the CONTRACTOR from responsibility for errors or omissions contained therein. Favorable review by the DESIGN CONSULTANT shall not relieve the CONTRACTOR of their obligation to coordinate, field verify all dimensions and meet safety requirements and all other requirements of laws, nor constitute a Contract Change Order. Favorable review by the DESIGN CONSULTANT will not constitute acceptance by the DESIGN CONSULTANT of any responsibility for the accuracy, coordination, and completeness of the submittals or the items of equipment represented on the submittals.

END OF SECTION

SECTION 01350

RECORD DOCUMENTS

PART 1 GENERAL

1.01 DESCRIPTION

- A. This Section describes the requirements for maintaining records of actual conditions in the field and for changes in the Work as contained on the As-Built drawings and transcribed to become the Record Documents.
- B. The purpose of final Project Record Documents is to provide factual information regarding all aspects of the Work, both concealed and visible, to enable future modifications of the Work to proceed without lengthy and expensive site measurement, investigation, and examination.
- C. Drawings shall be updated weekly. Progress payments may be delayed until record As-Built drawings are updated to meet requirements and date of pay request.

1.02 DOCUMENTS REQUIRED

- A. Maintain at the site the following record documents to be turned over to the DISTRICT upon request for Substantial Completion:
 - 1. Drawings.
 - 2. Specifications.
 - 3. Change Orders and other modifications to the Contract.
 - 4. Field Instructions and other written instructions from the DISTRICT'S Representative.
 - 5. Reviewed shop drawings, product data, and samples.
 - 6. Test reports.
 - 7. Requests for Information.
 - 8. Claims.
 - 9. Training.

1.03 MAINTENANCE OF DOCUMENTS AND SAMPLES

- A. Store record documents and samples in CONTRACTOR'S field office apart from documents used for construction.
 - 1. Provide files and racks for storage of documents.
 - 2. Provide locked cabinets or secure storage space for storage of samples.
- B. File documents and samples in a manner acceptable to the DISTRICT'S Representative.

- C. Make documents and samples available at all times for inspection by the DISTRICT'S Representative.
- D. Update the document within 24 hours after receiving information that a change has occurred or clarification has been issued.

1.04 MARKING DEVICES

- A. Use marking pens for recording information in the color approved by the DISTRICT'S Representative.

1.05 RECORDING

- A. Label each document "AS-BUILT PROJECT RECORD" in neat, large printed letters.
- B. Record information concurrently with the construction process.
 - 1. Do not conceal any work until required information is recorded.
 - 2. Completely, accurately, and legibly record, to the satisfaction of the DISTRICT'S Representative, all deviations in construction, especially pipe and conduit locations, and any deviations caused by approved changes and/or clarifications to the Work.
 - 3. Use additional copies of prints, if necessary, to ensure legible recording of data.
 - 4. Date all entries.
 - 5. Call attention to the entry by drawing a "cloud" around the area affected.
 - 6. In the event of overlapping changes, use different colors for each change.
- C. Legibly mark drawings to record actual construction:
 - 1. Depths of various elements of foundation in relation to finish first floor datum.
 - 2. Horizontal and vertical locations of underground utilities and appurtenances, referenced to permit surface improvements.
 - 3. Locations of internal utilities and appurtenances concealed in the construction, referenced to visible and accessible features of the structure.
 - 4. Field changes of dimension and detail.
 - 5. Changes made reflecting approved changes to the Work.
 - 6. Details not on original Contract Drawings.
- D. Legibly mark each Section of the Specifications to record:
 - 1. Manufacturer's trade name, catalog number, and supplier of each product and item of equipment installed.
 - 2. Changes made reflecting approved changes to the Work.
- E. Maintain shop drawings as record drawings. Legibly annotate shop drawings to record changes made after approval.
- F. Prior to submitting each request for payment, secure approval from the DISTRICT'S Representative of the current status of record documents.

- G. Periodic payments or portions thereof to the CONTRACTOR may be withheld until the DISTRICT'S Representative verifies that all as-built information to date has been properly recorded on project record documents.

1.06 CONVERSION OF COORDINATION DRAWINGS AND SCHEMATIC LAYOUTS

- A. The drawings, arrangements of conduits, circuits, piping, ducts, and similar items are shown schematically and are not intended to portray precise physical layout. The final physical arrangement is determined by the CONTRACTOR, subject to the approval of the ENGINEER, and shall be accurately recorded by the CONTRACTOR on the record documents.
- B. Show on the job set of record drawings, by dimension accurate to one-inch, the centerline of each run of all items specified in the preceding paragraph.
 - 1. Clearly identify the item by accurate note such as "cast iron drain" or "galvanized flashing", etc.
 - 2. Show by symbol or note the vertical location of the item ("6 inches below slab", "in ceiling plenum", "exposed", etc.).
 - 3. Make identification sufficiently descriptive that it may be related reliably to the Specifications.
- C. Coordinate with the Coordination Drawings.

1.07 FINAL PROJECT RECORD DOCUMENTS

- A. At a time nearing Substantial Completion of the Work, obtain from the ENGINEER through the CONSTRUCTION MANAGER the originals of the Contract Documents. The CONTRACTOR shall reproduce and provide one set of mylar reproducibles from the original transparencies. The CONTRACTOR will complete the As-Built prints.
- B. Obtain approval from the PROJECT INSPECTOR of all data recorded on the As-Built set of prints.
- C. After Substantial Completion, carefully transfer all data shown on the job set of As-Built Record Drawings to the corresponding transparencies, coordinating the information as required.
- D. Clearly indicate at each affected detail and other drawings a full description of changes made during construction, and the actual location of items as previously specified.
- E. "Cloud" all affected areas.
- F. Stamp each record drawing with the following information:
 - 1. Project Record Document.
 - 2. Prepared by: CONTRACTOR'S name, permanent address.
 - 3. Date prepared.
 - 4. CONTRACTOR'S signature.

1.08 SUBMITTALS

- A. Submit the complete set of As-Built Project Record Documents to the CONSTRUCTION MANAGER upon request for Substantial Completion.
- B. Participate in review meetings with the DISTRICT'S Representative and the ENGINEER as required.
- C. Make changes and promptly deliver the final Project Record Documents on the Mylar Transparencies to the DISTRICT'S Representative.
- D. Accompany submittal with transmittal letter as specified in Section 01330 Submittal Procedures. Include a signed certification that each document, as submitted, is complete and accurate.

END OF SECTION

SECTION 01354
HAZARDOUS MATERIAL PROCEDURES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: procedures required when encountering hazardous materials at the Work site.

1.02 REFERENCES

- A. American Conference of Government Industrial Hygienists (ACGHI).
- B. American National Standards Institute (ANSI).
- C. California Health and Safety Code, Section 25117.
- D. State of California Code of Regulations (CCR):
 - 1. Title 8. Industrial Relations.
 - 2. Title 22. Social Security.
- E. National Institute for Occupational Safety and Health (NIOSH).
- F. Occupational Safety and Health Administration (OSHA).
- G. Society for Protective Coatings (SPCC):
 - 1. Guide 6 – Guide for Containing Debris Generated During Paint Removal Operations.
 - 2. Guide 7 – Guide for Disposal of Lead-Contamination Surface Preparation Debris. PA
 - 3. Guide 3 – A Guide to Safety in Paint Application.
- H. United States Environmental Protection Agency (EPA).
- I. United States Code of Federal Regulation (CFR):
 - 1. Title 29 – Labor.
 - 2. Title 40 – Protection of Environment.

1.03 SUBMITTALS

- A. Submit laboratory reports, hazardous material removal plans, and certifications.

1.04 OPERATING DIGESTERS

- A. Observe safety precautions in vicinity of operating digesters which contain digester gases, including methane, hydrogen sulfide, and carbon dioxide.

1.05 HAZARDOUS MATERIALS PROCEDURES

- A. Hazardous materials are those defined by California Health and Safety Code, Section 25117.
- B. When hazardous materials have been found:
 - 1. Prepare and initiate implementation of plan of action.
 - 2. Notify immediately OWNER, ENGINEER, and other affected persons.
 - 3. Notify such agencies as are required to be notified by Laws and Regulations with the times stipulated by such Laws and Regulations.
 - 4. Designate a Certified Industrial Hygienist to issue pertinent instructions and recommendations for protection of workers and other affected persons' health and safety.
 - 5. Identify and contact subcontractors and licensed personnel qualified to undertake storage, removal, transportation, disposal, and other remedial work required by, and in accordance with, laws and regulations.
- C. When hazardous materials have been found that were identified by the OWNER:
 - 1. Prepare and initiate implementation of plan of action.
 - 2. Notify such agencies as are required to be notified by Laws and Regulations with the times stipulated by such Laws and Regulations.
 - 3. Designate a Certified Industrial Hygienist to issue pertinent instructions and recommendations for protection of workers and other affected persons' health and safety.
 - 4. Identify and contact subcontractors and licensed personnel qualified to undertake storage, removal, transportation, disposal, and other remedial work required by, and in accordance with, laws and regulations.
- D. Forward to ENGINEER, copies of reports, permits, receipts, and other documentation related to remedial work.
- E. Assume responsibility for worker health and safety, including health and safety of subcontractors and their workers.
 - 1. Instruct workers on recognition and reporting of materials that may be hazardous.
- F. File requests for adjustments to Contract Times and Contract Price due to the finding of Hazardous Materials in the Work site in accordance with Contract Documents.
 - 1. Minimize delays by continuing performance of the Work in areas not affected by hazardous materials operations.

1.06 LEAD PAINT REMOVAL AND DISPOSAL

- A. Existing paint on the interior and exterior surfaces that may contain lead in concentrations, which will require implementation of hazardous material compliance procedures as legislated by the following:
 - 1. United States Code of Federal Regulations, Title 29 and Title 40.
 - 2. State of California Code of Regulations, Title 8 and Title 22.
- B. Refer to Appendix F identifying locations that have lead containing materials (LCM).
- C. Submit a plan for the removal, containment, and disposal of lead-based paint and associated debris.
 - 1. Submit ten (10) copies of plan.
- D. Prior to beginning work associated with the removal, containment, and disposal of lead-based paints, prepare and submit to the ENGINEER for review six (6) copies of the following:
 - 1. Listing of lead paint removal equipment to be used.
 - 2. Outline of procedures to be used to remove lead paint.
 - 3. Data and specifications describing chemical stripping materials to be used.
 - 4. Data and specifications describing abrasive blast materials and grit size to be used.
 - 5. Plan describing lead paint removal, hazardous waste debris containment, and hazardous waste disposal methods.
 - 6. Safety plan, consisting of a written plan of action covering operational requirements for safe removal of lead paint, safe handling and containment of waste and debris generated by the operation, and safe disposal of hazardous waste and non-hazardous waste materials, complying with the most stringent requirements of the following:
 - a. Equipment and material manufacturer's safety sheets.
 - b. SSPC-PA Guide 3.
 - c. CFR 1910.
- E. Carry out lead paint removal, containment, and disposal work in accordance with the following SSPC guidelines:
 - 1. SSPC-Guide 6.
 - 2. SSPC-Guide 7.
- F. Lead paint removal methods acceptable for use as described in SSPC-Guide include:
 - 1. Open Abrasive Blast Cleaning with Expendable Abrasive.
 - 2. Open Abrasive Blast Cleaning with Recyclable Abrasive.
 - 3. Closed Abrasive Blast Cleaning with Recyclable Abrasive.
 - 4. Chemical Stripping.
- G. Assume responsibility for the proper utilization of the paint removal method selected. When abrasive blast cleaning is selected to remove lead-based paint, comply with all applicable federal, state, and local air quality, pollution, and environmental control regulations for blast cleaning. When chemical stripping is selected to remove the

lead based paint, adhere to the chemical manufacturer's recommendations for the application of the product, the removal of the paint, and the containment of the debris.

- H. Lead paint removal work shall be performed by a CONTRACTOR having prior experience in the removal method selected and shall provide at least five (5) references of similar projects completed, three (3) of which must have been completed within the past twelve (12) months, documenting their experience.
- I. Utilize a Class 3 containment and ventilation system as described in SSPC-Guide 6 during lead paint removal and containment procedures. Comply with the following requirements as described in SSPC-Guide 6:
 - 1. Containment materials: Type A1 – Rigid or Type A2 – Flexible.
 - 2. Permeability of containment materials: Type B1 – Air Impermeable.
 - 3. Support structure: Type C1 – Rigid or Type C2 – Flexible Support Structure.
 - 4. Joints: Type D1 – Fully Sealed Joints.
 - 5. Entryways: Type E2 – Overlapping Door Tarps.
 - 6. Air makeup system: Type F1 – Controlled Air Makeup.
 - 7. Input air flow system: Type G1 – Forced Input Air Flow.
 - 8. Air flow air pressure: Type H2 – Visual Verification.
 - 9. Air movement: In accordance with Type I1 – Minimum Air Movement Specified.
 - 10. Exhaust dust filtration system: Type J1 – Air Filtration System.
 - 11. Method for assessing quantity of emissions from site: Method A: Visible emissions with a Level O emissions requirement. Perform abrasive blasting inside containment structures.
- J. Do not leave spent abrasive blast material, chemical stripping material, or lead paint debris uncontained on the project site overnight.
- K. Test each container of paint debris, spent blast cleaning abrasive, chemical stripping debris, and other waste material generated by the operation to determine the waste material hazardous waste classification.
- L. Assume responsibility for the disposal of lead paint waste and associated waste generated by the removal of the lead paint and the preparation of the surfaces for recoating. Dispose in accordance with applicable federal, state, and local requirements and regulations.
- M. Accurately complete the Uniform Hazardous Waste Manifest included at the end of SSPC-Guide 7. Indicate on the Manifest that the OWNER is the hazardous waste generator, and obtain the OWNER's Environmental Protection Agency identification number for use in completing the Manifest.

1.07 ASBESTOS MATERIALS

- A. It is the specific intent of these Contract Documents to exclude from the Work any and all products or materials containing asbestos. No products containing asbestos shall be incorporated in the Work.

- B. Refer to Appendix F identifying locations that have asbestos containing materials (ACM). The report also designates the condition of the ACM in each location as either friable or non-friable.
- C. Removal of existing ACM shall be performed by a firm that is registered by Cal-OSHA and certified by the State Contractors Licensing Board and shall be a California Licensed Abatement Contractor.
- D. Submit ten (10) copies of plan for the removal, containment, and disposal of ACM.
- E. Submit six (6) copies of abatement license of ACM removal contractor.

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 requirements:
 - 1. Building code.
 - 2. Electrical code.
 - 3. Energy code.
 - 4. Fire code.
 - 5. Mechanical code.
 - 6. Plumbing code.

1.02 REFERENCES

- A. State or Local Building Codes and Amendments.
 - 1. California Code of Regulations (CCR),
 - a. Title 24: California Building Standards Code.
 - 1) California Building Code -2010 (CBC). (Title 24, Part 2.)
 - 2) California Electrical Code -2010 (CEC). (Title 24, Part 3.)
 - 3) California Mechanical Code -2010 (CMC). (Title 24, Part 4.)
 - 4) California Plumbing Code -2010 (CPC). (Title 24, Part 5.)
 - 5) California Energy Code -2010 (CEC). (Title 24, Part 6.)
 - 6) California Fire Code -2010 (CFC). (Title 24, Part 9.)

1.03 SYSTEM DESCRIPTION

- A. Design requirements:
 - 1. Building code:
 - a. California Building Code.
 - 2. Electrical code:
 - a. NFPA 70: National Electric Code.
 - b. NFPA 70E: Standard for Electrical Safety in the Workplace.
 - c. California Electrical Code.
 - 3. Energy conservation code:
 - a. International Energy Conservation Code.
 - b. California Energy Code.
 - 4. Fire code:
 - a. International Fire Code.
 - b. California Fire Code.
 - 5. Mechanical codes:
 - a. International Mechanical Code.
 - b. California Mechanical Code.

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6. Plumbing code:
 - a. International Plumbing Code.
 - b. California Plumbing Code.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01450

QUALITY CONTROL

PART 1 GENERAL

1.01 GENERAL

- A. Where the Contract Documents require work to be field tested or approved, it shall be tested in the presence of the CONSTRUCTION MANAGER or its authorized representative. The CONSTRUCTION MANAGER shall have the right to witness all on-site tests performed by the CONTRACTOR and any shop tests. The results of any tests performed by the CONTRACTOR shall be made available for the information of the CONSTRUCTION MANAGER. Inspections, tests or favorable reviews by the CONSTRUCTION MANAGER shall not relieve the CONTRACTOR of its obligation to perform the work in accordance with the requirements of the Contract Documents or for its sole responsibility to the quality of workmanship and materials.
- B. Except as specifically required under the technical specifications for testing and inspection, all tests for materials furnished by the CONTRACTOR will be done in accordance with commonly recognized standards of national organizations. Where tests are to be performed by the CONSTRUCTION MANAGER or an independent testing laboratory or agency, the CONTRACTOR will provide all samples of materials without charge. The CONSTRUCTION MANAGER and not the CONTRACTOR will select the sample or samples of materials to be tested. No material for which the Contract Documents require the submittal and approval of tests, certificates of compliance or other documentation shall be incorporated in the work until submittal and approval of the submittal has been made.
- C. The CONTRACTOR shall provide safe access for the CONSTRUCTION MANAGER and its inspectors to inspect the quality of work and the works conformance with the Contract Documents. The CONTRACTOR shall furnish the CONSTRUCTION MANAGER the necessary labor and facilities for such things as excavation in compacted fills to the depths required to take samples and/or density tests. The CONTRACTOR shall provide adequate lighting, ventilation, ladders and other equipment or protective facilities as may be necessary for the safe performance of inspections.
- D. Upon completion of the Work, the CONSTRUCTION MANAGER will conduct a final inspection. Records shall be available at all reasonable hours for inspection by other local and State agencies to ascertain compliance with laws and regulations.

1.02 NOTICE

- A. The CONTRACTOR shall notify the CONSTRUCTION MANAGER at least 24 hours before any field testing or special inspections are required to be performed by the

CONSTRUCTION MANAGER or the independent testing laboratory furnished by the OWNER. The CONTRACTOR shall notify the CONSTRUCTION MANAGER at least two hours before any inspection is required to be performed or to witness the CONTRACTOR'S on-site field testing.

- B. Whenever the CONTRACTOR varies the period during which work is carried on each day, the CONTRACTOR shall give the CONSTRUCTION MANAGER due notice so proper and timely inspection may be provided. Any work done in the absence of the CONSTRUCTION MANAGER shall be subject to rejection by the CONSTRUCTION MANAGER and/or the OWNER.

PART 2 QUALITY CONTROL

2.01 QUALITY CONTROL

- A. All materials and equipment shall be new and of the specified quality and equal to the samples found to be acceptable by the DESIGN CONSULTANT if samples have been submitted. It shall be the duty of the CONTRACTOR to call the CONSTRUCTION MANAGER'S attention to apparent errors or omissions and request instructions before proceeding with the Work. The CONSTRUCTION MANAGER may, by appropriate instructions, correct errors and supply omissions not involving extra cost, which instructions shall be as binding upon the CONTRACTOR as though contained in the original Contract Documents.
- B. At the option of the CONSTRUCTION MANAGER, materials and equipment to be supplied under this Contract will be tested and inspected either at their place of origin or at the site of the Work. The CONTRACTOR shall give the CONSTRUCTION MANAGER written notification at least 30 days prior to the shipment of materials and equipment to be tested and inspected at point of origin. Satisfactory tests and inspections at the point of origin shall not be construed as a final acceptance of the materials and equipment nor shall such tests and inspections preclude retesting or re-inspection at the site of the Work.
- C. Inspection of the Work by the OWNER, CONSTRUCTION MANAGER and/or DESIGN CONSULTANT shall not relieve the CONTRACTOR of its obligations to conduct comprehensive inspections of the Work and to furnish materials and perform acceptable Work, and to provide adequate safety precautions, in conformance with the intent of the Contract.

PART 3 INSPECTION

3.01 INSPECTION

- A. All work and materials are subject to the inspection of the CONSTRUCTION MANAGER. The CONTRACTOR shall notify the CONSTRUCTION MANAGER before noon of the working day before inspection is required. If the Specifications, the CONSTRUCTION MANAGER'S instructions, laws, ordinances, or any public authority require any work to be specially tested or approved, the CONTRACTOR shall give timely notice, in writing, of its readiness for inspection. Unless otherwise determined

by the CONSTRUCTION MANAGER, all inspections shall be done only in the presence of the CONSTRUCTION MANAGER or its authorized representatives. The OWNER, CONSTRUCTION MANAGER, DESIGN CONSULTANT and authorized government agents and their representatives shall at all times be provided safe access to the Work wherever it is in preparation or progress and to all warehouses and storage yards wherein materials and equipment are stored, and the CONTRACTOR shall provide facilities for such access and for inspection, including maintenance of temporary and permanent access. Inspection of the Work shall not relieve the CONTRACTOR of the obligation to fulfill all conditions of the Contract, and improper work will be subject to rejection. Work and materials not meeting such requirements shall be made good and unsuitable work or materials may be rejected; notwithstanding that such work or materials have been previously inspected by the CONSTRUCTION MANAGER or that payment therefore has been included in a progress estimate.

3.02 WORK COVERED PRIOR TO INSPECTION AND/OR TESTING

- A. No portion of any work or installed materials shall be covered or concealed in any manner whatsoever without first being inspected by the CONSTRUCTION MANAGER. If any work should be covered up without the approval or consent of the CONSTRUCTION MANAGER, the CONSTRUCTION MANAGER shall have the authority to require that such work be uncovered for examination; defective work, if any, corrected; and recovered at the CONTRACTOR'S expense.

PART 4 SAMPLES AND TESTS

4.01 SAMPLES AND TESTS

- A. At the option of the CONSTRUCTION MANAGER, the source of supply of materials for the Work shall be subject to tests and inspection before the delivery is started and before such materials are used in the Work. Representative preliminary samples of the character and quality prescribed shall be submitted by the CONTRACTOR or producer of materials to be used in the Work in sufficient quantities or amounts for testing or examination.
- B. All tests of materials furnished by the CONTRACTOR shall be made in accordance with the commonly recognized standards of national technical organizations, and such special methods and tests as are prescribed in the Contract Documents.
- C. Certificates of compliance shall be provided by the CONTRACTOR as required in the Technical Specifications.

4.02 SAMPLING

- A. The CONTRACTOR shall furnish such samples of materials as are requested by the CONSTRUCTION MANAGER, without charge. No material shall be used until the CONSTRUCTION MANAGER has had the opportunity to test or examine such materials. Samples will be secured and tested whenever necessary to determine the quality of the material. Samples and test specimens prepared at the jobsite, such as concrete test cylinders, shall be taken or prepared by the CONSTRUCTION MANAGER or Testing Firm in the presence and with the assistance of the CONTRACTOR.

4.03 TESTING

- A. Unless otherwise provided, all initial testing for concrete and soils shall be at no expense to the CONTRACTOR and shall be performed in the OWNER'S laboratory or in a laboratory designated by the OWNER. Any retesting required due to failed test or defective material or sample shall be at the CONTRACTOR'S expense. When required by the Contract or the CONSTRUCTION MANAGER, the CONTRACTOR shall furnish, at no extra charge, certificates of tests of materials and equipment made at the point of manufacture by a recognized testing laboratory.
- B. The CONTRACTOR is responsible for all system and equipment testing as provided for in these Contract Documents.

4.04 TEST STANDARDS

- A. All sampling, specimen preparation, and testing of materials shall be in accordance with the standards of nationally recognized technical organizations.
- B. The physical characteristics of all materials not particularly specified shall conform to the latest standards published by the American Society for Testing Materials, where applicable.

END OF SECTION

SECTION 01458

TESTING AND TESTING LABORATORY SERVICES

PART 1 GENERAL

1.01 SUMMARY

- A. The CONTRACTOR shall retain the services of an Independent Testing Laboratory to perform materials testing specifically indicated in the Contract Documents and the ENGINEER may at any time elect to have materials and equipment tested for conformity with the Contract Documents.
 - 1. Cooperate with the laboratory to facilitate the execution of its required services.
 - 2. Employment of the laboratory shall in no way relieve CONTRACTOR'S obligations to perform the Work of the Contract.

1.02 RELATED REQUIREMENTS

- A. Conditions of the Contract: Inspections and testing required by laws, ordinances, rules, regulations, orders or approvals of public authorities.
- B. Respective sections of specifications: Certification of products.
- C. Each specification section listed: Laboratory tests required and standards for testing.
- D. Testing laboratory inspection, sampling and testing is required for, but not limited to concrete work, rebar, asphalt mix, soil densities and compaction tests.

1.03 LIMITATIONS OF AUTHORITY OF TESTING LABORATORY

- A. Laboratory is not authorized to:
 - 1. Release, revoke, alter or enlarge on requirements of Contract Documents.
 - 2. Approve or accept any portion of the Work.
 - 3. Perform any duties of the CONTRACTOR.

1.04 CONTRACTOR'S RESPONSIBILITIES

- A. Cooperate with laboratory personnel, and provide access to Work and to manufacturer's operations.
- B. Secure and deliver to the laboratory adequate quantities of representational samples of materials proposed to be used and which require testing.
- C. Provide to the laboratory the preliminary design mix proposed to be used for concrete, and other materials mixes, which require control by the testing laboratory.

- D. Materials and equipment used in the performance of work under this Contract are subject to inspection and testing at the point of manufacture or fabrication.
 - 1. Standard specifications for quality and workmanship are indicated in the Contract Documents.
 - 2. The ENGINEER may require the CONTRACTOR to provide statements or certificates from the manufacturers and fabricators that the materials and equipment provided by them are manufactured or fabricated in full accordance with the standard specifications for quality and workmanship indicated in the CONTRACTOR Documents.
 - 3. Costs of this testing and providing statements and certificates shall be a subsidiary obligation of the CONTRACTOR, and no extra charge to the OWNER shall be allowed on account of such testing and certification.
- E. Furnish incidental labor and facilities:
 - 1. To provide access to Work to be tested.
 - 2. To obtain and handle samples at the Project Site or at the source of the product to be tested.
 - 3. To facilitate inspections and tests.
 - 4. For storage and curing of test samples.
- F. Notify laboratory sufficiently in advance of operations to allow for laboratory assignment of personnel and scheduling of tests.
 - 1. When tests or inspections cannot be performed after such notice, the CONTRACTOR shall reimburse the laboratory personnel for travel time incurred due to the CONTRACTOR'S negligence.
- G. Employ and pay for the services of a qualified independent testing laboratory to perform inspections, sampling, and testing required.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

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SECTION 01500
CONTRACTOR'S UTILITIES

PART 1 GENERAL

1.01 OFFICE

- A. The CONTRACTOR shall maintain a suitable office at the site of the work.

1.02 POWER

- A. The CONTRACTOR shall provide power for construction at the plant site. CONTRACTOR shall make arrangements with the electrical utility and with the OWNER for power takeoff points, voltage and phasing requirements, transformers and metering and shall pay the costs and fees arising therefrom. The CONTRACTOR shall provide the special connections required for this work.

1.03 TELEPHONE

- A. The CONTRACTOR shall provide telephone service at their construction site office. Radio telephone service is not acceptable as a substitute for telephone service.

1.04 SANITARY FACILITIES

- A. The CONTRACTOR shall provide toilet and wash-up facilities for their work force at the site of work. They shall comply with applicable laws, ordinances, and regulations pertaining to the public health and sanitation of dwellings and camps.

1.05 WATER

- A. The CONTRACTOR shall provide their own water for construction purposes. This may be done by negotiation with the OWNER to use their water. Appropriate metering and fair compensation for water used by the CONTRACTOR shall be made a part of the agreement for its use.
- B. No permanent connections to potable water systems shall be permitted.

END OF SECTION

SECTION 01520
CONTRACTOR'S OPERATIONS

PART 1 GENERAL

1.01 SECURITY

- A. The CONTRACTOR shall at all times be responsible for the security of their facilities and equipment. The OWNER will not take any responsibility for missing or damaged equipment, tools, or personal belongings.

1.02 OFFICE

- A. During the performance of the Contract, the CONTRACTOR shall maintain a suitable office at the site of the work, which shall be the headquarters of the CONTRACTOR'S Representative. The location of the CONTRACTOR'S office within the project site shall be subject to review by the CONSTRUCTION MANAGER.

1.03 WORKSHOP AND STORAGE FACILITIES

- A. The CONTRACTOR shall provide off-site storage buildings for the protection of equipment, materials, supplies, and tools and shall ensure that the building used for the storage of materials, which deteriorate when exposed to moisture is moisture-proof.

1.04 PARKING

- A. Owing to the limited room available at the site, the CONTRACTOR shall provide off-site, all-weather parking for their workmen and the workmen employed by all subcontractors and suppliers providing work at the site. A shuttle bus service, if required, shall be provided to transport personnel to and from the parking area and the Project Site. The provisions relating to the control of site conditions under paragraph 1.01 A shall apply as well to the parking area.

PART 2 ENVIRONMENTAL CONTROL

2.01 SITE CONDITIONS

- A. Throughout all phases of construction, including suspension of work, and until final acceptance of the project, the CONTRACTOR shall keep the work site clean and free from rubbish and debris. The CONTRACTOR shall also abate dust nuisance by cleaning, sweeping, and sprinkling with water, or other means as necessary. The use of water resulting in mud on public streets will not be permitted as a substitute for sweeping or other methods. During inclement weather, the CONTRACTOR shall preserve all access roadways and walkways in serviceable condition through the

maintenance of adequate drainage provisions and the placement of crushed rock. Existing drainage facilities shall be kept free of debris and silt and water shall not be allowed to accumulate and stand upon the site. Should the CONTRACTOR fail to take the measures necessary, in the opinion of the CONSTRUCTION MANAGER, to control dust, mud or drainage within six (6) hours of written notification that such measures are required; the OWNER reserves the right to implement the necessary actions and deduct all costs thereof from payments due the CONTRACTOR.

2.02 CLEANUP

- A. Materials and equipment shall be removed from the site as soon as they are no longer necessary, and upon completion of the work and before final inspection the entire work site shall be cleared of equipment, unused materials and rubbish so as to present a satisfactory clean and neat appearance. All cleanup cost included in the CONTRACTOR'S total lump sum for the work.
- B. Care shall be taken to prevent spillage at the project site. Any such spillage shall be removed immediately and the area cleaned.
- C. Excess excavated material from catch basins or similar structures shall be removed from the site immediately. Sufficient material may remain for use as backfill if permitted by the specifications. Forms and form lumber shall be removed from the site as soon as practicable after stripping.
- D. Earth dams will not be permitted at catch basin openings, local depressions, or elsewhere, except in time of emergency. Temporary dams of sand bags, asphaltic concrete, or other acceptable material may be permitted when necessary to protect the work, provided their use does not create a hazard or nuisance to the public. Such dams shall be removed from the site as soon as their use is no longer necessary.
- E. Failure of the CONTRACTOR to comply with the CONSTRUCTION MANAGER'S cleanup orders may result in an order to suspend work until the condition is corrected. No additional compensation will be allowed as a result of such suspension.

2.03 AIR POLLUTION CONTROL

- A. The CONTRACTOR shall not discharge smoke, dust, or any other air contaminants into the atmosphere in such quantity as will violate the regulations of any legally constituted authority. CONTRACTOR shall also abate dust nuisance by cleaning, sweeping, and sprinkling with water, or other means as necessary. The use of water, in amounts which result in mud on public streets, is not acceptable as a substitute for sweeping or other methods.

2.04 SANITATION

- A. Wastewater flows shall not be interrupted. Should the CONTRACTOR disrupt existing sewerage facilities, wastewater shall be conveyed in closed conduits and

disposed of in a sanitary sewer system. Wastewater shall not be permitted to flow in trenches or be covered by backfill.

- B. Bypassing of wastewater is prohibited. Where the CONTRACTOR chooses to provide temporary pumping of wastewater, he shall request authorization from the ENGINEER and have their proposed pumping facility approved by the ENGINEER through the CONSTRUCTION MANAGER. One hundred percent standby equipment shall be provided for all bypass pumping operations.

2.05 NOISE CONTROL

- A. Between 7:30 p.m. and 7:00 a.m., noise from CONTRACTOR'S operation shall not exceed limits established by applicable laws or regulations and in no event shall exceed 86 dBA at a distance of 50-feet from the noise source.

2.06 BLASTING

- A. Blasting, if required, shall be included in the cost of the contract and shall be done in strict accordance with rules established by the State of California.

END OF SECTION

SECTION 01600

PRODUCT REQUIREMENTS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Product requirements; product selection; products schedule; execution; manufacturer's instructions; and delivery, handling, and storage.

1.02 DEFINITIONS

- A. Execution: Inclusive of performance, workmanship, installation, erection, application, field fabrication, field quality control, and protection of installed products.
- B. Products: Inclusive of material, equipment, systems, shop fabrications, mixing, source quality control.

1.03 PRODUCT 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 5 years operational experience, unless otherwise specified, whichever is more stringent.
 - 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 in continental United States.

1.04 PRODUCT SELECTION

- A. When products are specified by standard or specification designations of technical societies, organizations, or associations only, provide products which 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 1 of named manufacturers which 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 1 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 1 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 equal 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 1 manufacturer followed by "or Equal," provide:
 - 1. Products meeting or exceeding Specifications by specified manufacturer.
 - 2. Accepted or equal.

1.05 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.

1.06 QUALITY ASSURANCE

- A. Employ entities, which 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, AND STORAGE

- 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. Verify compliance with Contract Documents, correct quantities, and undamaged condition of products. Immediately store and protect products and materials until installed in Work.
- E. Store products with seals and legible labels intact.
- F. Store moisture sensitive products in weathertight enclosures.
- G. Maintain products within temperature and humidity ranges required or recommended by manufacturer.
- H. Connect and operate space heaters during storage when ambient temperatures fall below temperatures recommended by manufacturer.
- I. Protect painted surfaces against impact, abrasion, discoloration, and other damage. Repaint damaged painted surfaces.
- J. Exterior storage of fabricated products:
1. Place on aboveground supports which allow for drainage.
 2. Cover products subject to deterioration with impervious sheet covering.
 3. Provide ventilation to prevent condensation under covering.
- K. Store loose granular materials on solid surfaces in well-drained area. Prevent materials mixing with foreign matter.
- L. Provide access for inspection.
- M. 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.

1.08 MANUFACTURER'S INSTRUCTIONS

- A. Deliver, handle, store, install, erect, or apply products in accordance with manufacturer's instructions, Contract Documents, and industry standards.

- B. Periodically inspect to assure products are undamaged and maintained under required conditions.

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.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the CONTRACTOR'S responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR'S Work.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
 - 4. Division 1 - General Conditions.

1.02 REFERENCES

- A. American Society of Civil Engineers (ASCE):
 - 1. 7-05 - Minimum Design Loads for Buildings and Other Structures.

1.03 SYSTEM DESCRIPTION

- A. Design requirements:
 - 1. Design in accordance with the requirements of the building code as specified in Division 1:
 - a. Design spectral acceleration at short period, S_{DS} : 0.595g.
 - b. Component amplification factor, a_p : In accordance with ASCE 7-05, Tables 13.5-1 and 13.6-1.
 - c. Component response modification factor, R_p : In accordance with ASCE 7-05, Tables 13.5-1 and 13.6-1.
 - d. Component importance factor, I_p : 1.50.
 - 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. Do not use anchor bolts fabricated from rod stock with an L or J shape.
 - a. 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.
 - b. 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 01660

INSTALLATION, TESTING, AND COMMISSIONING

PART 1 GENERAL

1.01 DESCRIPTION

- A. This Section specifies the installation, testing, and commissioning for all mechanical, electrical and instrumentation systems.

1.02 QUALITY ASSURANCE

A. Installation

- 1. All mechanical, electrical, and instrumentation equipment provided under this contract shall be installed in conformity with the details shown and specified and with the manufacturer's requirements. Should a manufacturer's installation recommendations conflict with specific requirements of these Contract Documents, the CONTRACTOR shall bring the matter to the attention of the ENGINEER. Any additional costs incurred arising out of changes in the Contract Documents authorized by the ENGINEER to accommodate manufacturer's installation recommendations will be considered extra work in accordance with the General Conditions. Any costs incurred by the CONTRACTOR through failure to timely notify the ENGINEER of a difference between the Contract Documents and manufacturer's installation requirements shall be borne by the CONTRACTOR.

B. Testing

- 1. General Requirements: All equipment and partially complete or fully completed portions of the work included in this contract shall be tested and inspected to demonstrate compliance with the contract requirements. Unless otherwise specified, all costs of testing, including temporary facilities and connections, shall be borne by the CONTRACTOR. For the purpose of this Section, equipment shall mean any mechanical, electrical, instrumentation, or other device with one or more moving parts or devices requiring an electrical, pneumatic or hydraulic connection. Installed structural facilities shall be tested for watertightness as specified in Section 03300 Cast-in-Place Concrete. Installed leakage tests and other piping tests shall be as specified in Division 15 Mechanical. Installed tests for heating, ventilation, and air conditioning systems shall be as specified in Division 15 Mechanical. Installed tests for electrical devices and systems shall be in accordance with Division 16 Electrical. Installed tests for instrumentation devices and systems shall be in accordance with Division 16 Electrical.
- 2. Approval for Testing: No tests specified herein shall be conducted until the item to be tested has been inspected and approval given by the ENGINEER for the application of such test.
- 3. Scope: Tests and inspection shall include:
 - a. The delivery acceptance test and inspections.

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- b. The installed tests and inspections including Pre-Operation Checkout and Operational Testing.
 - c. The commissioning of completed sections of the plant by OWNER'S personnel.
- 4. Testing Standards: Tests and inspections, unless otherwise specified or accepted, shall be in accordance with the recognized standards of the industry. The CONTRACTOR shall ensure that scheduling and performance of all tests are coordinated with involved subcontractors and suppliers.
- 5. Testing Forms: The form of evidence of satisfactory fulfillment of delivery acceptance test and inspection requirements shall be, at the discretion of the ENGINEER, either by tests and inspections carried out by approved persons or organizations. The CONTRACTOR shall provide and use forms which include all test information, including specified operational parameters. The forms used shall be acceptable in content to the ENGINEER.
- 6. Master Test Log Book: Prior to commencing testing and inspection, the CONTRACTOR shall submit to the ENGINEER the proposed format for the master test log book. The master test log book shall be maintained by the CONTRACTOR which shall cover all tests including piping, equipment, electrical, and instrumentation. The master test log book shall be provided with loose leaf pages which shall be copied weekly after updating for transmittal to the ENGINEER. At the completion of the project, the complete master test log book shall be submitted to the ENGINEER.
- 7. Delivery Acceptance Tests and Inspections: The delivery acceptance tests and inspections and any remedial work to correct deficiencies shall be at the CONTRACTOR'S expense for any equipment specified herein and shall include the following:
 - a. Test of items at the place of manufacture during and/or on completion of manufacture, comprising hydraulic pressure tests, electric and instrumentation subsystems tests, performance and operating tests and inspections in accordance with the relevant standards of the industry and more particularly as detailed in individual sections of these specifications to satisfy the ENGINEER that the items tested and inspected comply with the requirements of the Contract Documents.
 - b. Inspection of all items delivered at the site or to any authorized place of storage in order that the ENGINEER may be satisfied that such items are of the specified quality and workmanship and are in good order and condition at the time of delivery. The CONTRACTOR shall be prepared to remove all coverings, containers or crates to permit the ENGINEER to conduct his inspection. Should the ENGINEER find, in his opinion, indication of damage or deficient quality of workmanship, the CONTRACTOR shall remedy such deficiencies and provide the necessary documentation or conduct such tests deemed necessary by the ENGINEER to demonstrate compliance.
- 8. Installed Tests and Inspections: All equipment shall be tested by the CONTRACTOR to the satisfaction of the ENGINEER before any facility is placed in operation. Tests shall be as specified herein and shall be made to determine whether the equipment has been properly assembled, aligned, adjusted and connected. Any changes, adjustments or replacements required to make the equipment operate as specified shall be carried out by the CONTRACTOR as part of the work.

9. Procedures: Prior to receipt of any progress payments in excess of 60% of the CONTRACTOR'S lump sum bid for the work, the CONTRACTOR shall submit to the ENGINEER, in quintuplicate, details of the installed tests and inspection procedures he proposes to adopt for testing and start-up of all equipment to be operated singly and together, except when such procedures have been addressed in the Project Specifications. The procedures shall be divided into two distinct stages: pre-operation checkout and operation testing. Testing procedures shall be designed to duplicate, as nearly as possible, all conditions of operation and shall be carefully selected to ensure that the equipment is not damaged. Once the testing procedures have been reviewed by the ENGINEER, the CONTRACTOR shall produce checkout, alignment, adjustment and calibration signoff forms for each item of equipment to be used in the field by the CONTRACTOR and the ENGINEER jointly to ensure that each item of electrical, mechanical, and instrumentation equipment has been properly installed and tested. The CONTRACTOR is advised that failure to observe these precautions may place the acceptability of the subject equipment in question.
10. Pre-Operation Checkout: The installed tests and inspection procedures shall incorporate all requirements of these specifications and shall proceed in a logical, step wise sequence to ensure that all equipment has been properly serviced, aligned, connected, calibrated and adjusted prior to operation. Pre-operation checkout procedures shall include, but not necessarily be limited to:
 - a. Piping system pressure testing and cleaning as specified in Division 15 Mechanical.
 - b. Electrical system testing as specified in Division 16 Electrical.
 - c. Instrumentation system testing as specified in Division 16 Electrical.
 - d. Alignment of equipment.
 - e. Pre-operation lubrication.
11. Operational Testing: Once all affected equipment has been subjected to the required preoperational checkout procedures and the ENGINEER has witnessed and has not found deficiencies in that portion of the work, individual systems may be started and operated under simulated operating conditions to determine as nearly as possible whether the equipment and systems meet the requirements of these specifications. Potable water shall be employed for the testing of all liquid systems except gaseous, oil or chemical systems unless specified otherwise. Test media for these systems shall either be the intended fluid or a compatible substitute. The equipment shall be operated a sufficient period of time to determine machine operating characteristics, including temperatures and vibration; to observe performance characteristics; and to permit initial adjustment of operating controls. When testing requires the availability of auxiliary systems such as electrical power, compressed air, control air, or instrumentation which have not yet been placed in service, the CONTRACTOR shall provide acceptable substitute sources, capable of meeting the requirements of the machine, device or system, at no additional cost to the OWNER. Disposal methods for test media shall be subject to review and acceptance of the ENGINEER.
12. Repeated Tests: If under test, any portion of the work should fail to fulfill the contract requirements and is adjusted, altered, renewed or replaced, together with all other portions of the work as are affected thereby, shall, if so required by the ENGINEER, be repeated within reasonable time and in accordance with the

specified conditions. The CONTRACTOR shall pay to the OWNER all reasonable expenses incurred by the OWNER as a result of repeating such tests.

- a. Once simulated operation has been completed, all machines shall be rechecked for proper alignment, realigned, if necessary, and doweled in place. All equipment shall be checked for loose connections, unusual movement or other indications of improper operating characteristics. Any deficiencies shall be corrected to the satisfaction of the ENGINEER. All machines or devices which exhibit unusual or unacceptable operating characteristics shall be disassembled and inspected. They shall then be repaired or removed from the site and replaced at no cost to the OWNER.
13. Tolerances: Test results shall be within the tolerances set forth in the detailed specification sections of this Contract Document. If no tolerances have been specified, test results shall conform to tolerances established by recognized industry practice. Where, in the case of an otherwise satisfactory installed test, any doubt, dispute, or difference should arise between the ENGINEER and the CONTRACTOR regarding the test results or the methods or equipment used in the performance of such test, then the ENGINEER may order the test to be repeated. If the repeat test, using such modified methods or equipment as the ENGINEER may require, substantially confirms the previous test, then all costs in connection with the repeat test will be paid by the OWNER, otherwise the costs shall be borne by the CONTRACTOR. Where the results of any installed test fail to comply with the contract requirements for such test, then such remedial efforts and repeat tests as may be necessary to achieve the contract requirements shall be made by the CONTRACTOR at his expense.
14. CONTRACTOR Supplied Materials: Unless otherwise specified, the CONTRACTOR shall provide at no expense to the OWNER, all power, fuel, compressed air supplies, labor and all other necessary items and work required to complete all tests and inspection specified herein. The CONTRACTOR shall provide, at no expense to the OWNER, temporary heating, ventilating and air conditioning for any area requiring it in the case where permanent facilities are not complete and operable at the time of installed tests and inspections. Temporary facilities shall be maintained until permanent systems are in service.
15. Commissioning: After completion of the operation testing and certification by the ENGINEER that the systems did meet all performance requirements, commissioning will begin. The commissioning period for each system or system components shall be 20 working days except where specified otherwise. The CONTRACTOR shall remove all temporary piping or bulkheads that may have been in use during the operational testing. The OWNER'S operations and maintenance personnel will be responsible for operation of the plant or portion of the plant being operated during this period of time. The plant or portion thereof shall be fully operational, accepting all normal flow called for in design and performing all functions as designed. The CONTRACTOR and the equipment manufacturer's technical representative shall be available at all times during the commissioning period to provide immediate assistance in case of failure of any portion of the system being tested. At the end of the commissioning period and when all corrections required by the ENGINEER to assure a reliable and completely operational facility are complete, the ENGINEER shall issue a certificate of substantial completion. During the commissioning period, the OWNER shall be responsible for all normal operational costs and the

CONTRACTOR shall bear the costs of all necessary repairs or replacements, including labor and materials, required to keep the portion of the plant being commissioned, operational.

16. Training: During the operational testing phase of equipment, the CONTRACTOR shall make available experienced factory trained representatives of the manufacturers of all the various pieces of equipment, to train the OWNER'S personnel in the operation and maintenance thereof. The time required for this training shall be as specified herein for the specific piece of equipment. The CONTRACTOR shall notify the ENGINEER of the time of the training at least 14 days prior to the time of training.

PART 2 PRODUCTS

2.01 MATERIALS

A. Installation

1. Materials employed in the installation shall conform to the requirements of these Contract Documents and the recommendations of the equipment manufacturers.

B. Testing

1. Gages, Meters, Recorders, and Monitors: Gages, meters, recorders, and monitors shall be provided by the CONTRACTOR to supplement or augment the instrumentation system provided under this contract to properly demonstrate that all equipment fully satisfies the requirements of the Contract Documents. All devices employed for the purpose of measuring the performance of the facility's equipment and systems shall be specifically selected to be consistent with the variables to be monitored. All instruments shall be recently calibrated and the CONTRACTOR shall be prepared at all times to demonstrate, through recalibration, the accuracy of all instruments employed for testing purposes. Calibration procedures shall be in accordance with applicable standards of ASTM, ISA, and IEEE. The adequacy of all gages, meters, recorders and monitors shall be subject to review of the ENGINEER.
2. Records: The CONTRACTOR shall provide signoff forms for all installed and operational testing to be accomplished under this contract. The signoff forms shall be produced in quadruplicate on pressure sensitive paper. Signoff forms shall be provided for each item of mechanical, electrical, and instrumentation equipment provided or installed under this contract and shall contain provisions for recording relevant performance data for original testing and not less than three retests. Separate sections shall be provided to record values for the pre-operation checkout, initials of representatives of the equipment manufacturers, the CONTRACTOR, and the ENGINEER.
3. Master File: The CONTRACTOR shall maintain a master file of all equipment signoff sheets, which shall be available for inspection by the ENGINEER. Upon completion of testing, the CONTRACTOR shall furnish the ENGINEER with the original and two copies of the signoff sheet for each equipment item.

PART 3 EXECUTION

3.01 METHODS

A. Installation

1. All equipment and apparatus used in testing shall be installed by specialists properly skilled in the trades and professions required to assure first class workmanship. Where required by detailed specifications, the CONTRACTOR shall cause the installation of specific equipment testing items to be accomplished under the supervision of factory trained installation specialists furnished by the equipment manufacturers. The CONTRACTOR shall be prepared to document the skills and training of all workmen engaged in the installation of all testing equipment furnished either by the CONTRACTOR or the OWNER.

B. Testing

1. Testing shall proceed on the step by step basis in accordance with the CONTRACTOR'S written testing procedures. The CONTRACTOR'S testing work shall be accomplished by a skilled team of specialists under the direction of a coordinator whose sole responsibility shall be the orderly, systematic testing of all equipment, systems, structures, and the complete facility as a unit. Each individual step in the procedures shall be witnessed by a representative of the ENGINEER. During the plant operational testing period, all equipment and systems in operation shall be operated to the greatest extent practicable, at conditions which represent the full range of operating parameters as defined by this Contract Document.

END OF SECTION

SECTION 01700

RESTORATION OF IMPROVEMENTS

PART 1 GENERAL

1.01 STRUCTURES

- A. The CONTRACTOR shall remove such existing structures, including curbs, gutters, pipelines and utility poles, as may be necessary for the performance of the work and shall rebuild the structures thus removed in as good a condition as found and in accordance with applicable agency Standard Specifications. The CONTRACTOR shall also repair existing public or privately owned structures that may be damaged as a result of the work under this Contract.

1.02 ROADS AND STREETS

- A. Unless otherwise specified, roads and streets in which the surface is removed, broken, or damaged, or in which the ground has caved or settled during the work under this Contract, shall be resurfaced and brought to the original grade and section. Roadways used by the CONTRACTOR shall be cleaned and repaired. Before resurfacing material is placed, edges of pavements shall be trimmed back far enough to provide clean, solid, vertical faces, and shall be free of loose material. Repair work shall conform to the applicable agency standards and specifications.

1.03 CULTIVATED AREAS, LANDSCAPING, AND OTHER SURFACE IMPROVEMENTS

- A. Cultivated or planted areas, landscape materials (trees, shrubs, decorative walls, etc.) and other surface improvements which are damaged by actions of the CONTRACTOR shall be restored as nearly as possible to their original condition.
- B. Existing buildings, structures, equipment, water features, and fences shall be protected and replaced if damaged.

1.04 PROTECTION OF EXISTING INSTALLATIONS

- A. The CONTRACTOR shall immediately correct or replace existing equipment, utilities, controls or systems which are damaged as a result of his operations. Repairs shall be made in accordance with owner of the Utilities standard specifications.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

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SECTION 01730

OPERATION AND MAINTENANCE INFORMATION

PART 1 GENERAL

1.01 SCOPE

- A. When specified, operation and maintenance information shall be provided and shall consist of the names and addresses of the manufacturer, the nearest representative of the manufacturer, and the nearest supplier of the manufacturer's equipment and parts. In addition, one or more of the following items of information will be provided when specified.
1. Lubrication Information: This shall consist of the manufacturer's recommendations regarding the lubricants to be used and the lubrication schedule to be followed.
 2. Control Diagrams: Diagrams shall show internal and connection wiring.
 3. Start-up Procedures: These instructions consist of equipment manufacturer's recommendations for installation, adjustment, calibration, and troubleshooting. In addition, all information on the "Manufacturer's Installation Certification Form" and the "Manufacturer's Instruction Certification Form," shall be provided.
 4. Operating Procedures: These instructions consist of the equipment manufacturer's recommended step by step procedures for starting, operating, and stopping the equipment under specified modes of operation.
 5. Preventive Maintenance Procedures: These instructions consist of the equipment manufacturer's recommended steps and schedules for maintaining the equipment. In addition, all information on the "Equipment Maintenance Summary Form" shall be provided.
 6. Overhaul Instructions: These instructions consist of the manufacturer's directions for the disassembly, repair and reassembly of the equipment and any safety precautions that must be observed while performing the work.
 7. Parts List: This list consists of the generic title and identification number of each component part of the equipment.
 8. Spare Parts List: This list consists of the manufacturer's recommendations of number of parts which should be stored by the OWNER and any special storage precautions which may be required.
 9. Exploded View: Exploded or cut views of equipment shall be provided if available as a standard item of the manufacturer's information. When exploded or cut views are not available, plan and section views shall be provided with detailed callouts.
 10. Specific Information: When items of information not included in the above list are required, they will be provided as described in the specification for the equipment.

1.02 TRANSMITTAL PROCEDURE

- A. Three copies of the specified operation and maintenance information shall be provided. For ease of identification, each manufacturer's brochure and manual shall be appropriately labeled with the equipment name and equipment number as it

appears in the Contract Documents. The information shall be organized in the binders in numerical order by the equipment numbers assigned in the Contract Documents. The binders shall be provided with a table of contents and tab sheets to permit easy location of desired information. Binders shall be three ring binders.

- B. If manufacturer's standard brochures and manuals are used to describe operating and maintenance procedures, such brochures and manuals shall be modified to reflect only the model or series of equipment used on this project. Extraneous material shall be crossed out neatly or otherwise annotated or eliminated.

1.03 PAYMENT

- A. Acceptable operation and maintenance information must be delivered to the ENGINEER before the CONTRACTOR can be paid for more than 80 percent of the purchase value of that equipment. Purchase value shall be the net price for the equipment as given on the invoice. Acceptable operation and maintenance information for the project must be delivered to the ENGINEER prior to the project being 75 percent complete. Progress payments for work in excess of 75 percent completion will not be made until the specified acceptable operation and maintenance information has been delivered to the ENGINEER.

1.04 FIELD CHANGES

- A. Following the acceptable installation and operation of an equipment item, the item's instructions and procedures shall be modified and supplemented by the CONTRACTOR to reflect any field changes or information requiring field data.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01770
PROJECT CLOSEOUT

PART 1 GENERAL

1.01 GENERAL

- A. All construction shall meet the Public Works Occupancy Requirements prior to final acceptance. Public works occupancy requirements include, but are not limited to, the following:
1. All underground facilities.
 2. Asphalt concrete pavement.
 3. Portland cement concrete improvements which may include, but not limited to: curb; gutter; sidewalk; driveways; and access ramps.
 4. Finish grading within the street right-of-way.
 5. Pipeline testing
 6. Traffic regulatory signs, striping, and markings.
 7. All potential hazards removed within the street right-of-way.
 8. Street, and sidewalks and driveways cleaned.
 9. Improvements restored.

1.02 FINAL CLEANUP

- A. The CONTRACTOR shall promptly remove all rubbish, debris, unused materials, concrete forms, construction equipment, and temporary structures and facilities used during construction. Final acceptance of the Work by the DISTRICT will be withheld until the CONTRACTOR has satisfactorily complied with the foregoing requirements for final cleanup of the Project Site.

1.03 MEASUREMENT AND PAYMENT

- A. No separate payment or compensation shall be made for work of this Section.
- B. Full compensation for all costs associated with complying with requirements of this Section shall be considered as part of and included in payment for each bid item for which compliance is required.

1.04 FINAL SUBMITTALS

- A. The CONTRACTOR, prior to final acceptance, shall submit the following items to the ENGINEER:
1. Written guarantees or warranties.
 2. Record drawings as specified in Section 01350 Record Documents.
 3. Maintenance stock items, including special parts; spare parts; special tools.

4. Signed-off permits and/or certificates of inspection and acceptance by local governing agencies having jurisdiction.
5. Releases from all parties who are entitled to claims against the subject project, property, or improvement pursuant to the provisions of law.

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:
 - 1. Aggregate Base Course.
 - 2. Class 2 Permeable.
 - 3. Drain Rock.
 - 4. Gravel.
 - 5. Not used.
 - 6. Native Material.
 - 7. Sand.
 - 8. Select Material.
 - 9. Stabilization Material.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. C 117 - Standard Test Method for Materials Finer than 75- μ m (No. 200) Sieve in Mineral Aggregates by Washing.
 - 2. C 131 - Standard Test Method for Resistance to Degradation of Small-Size Course Aggregate by Abrasion and Impact in the Los Angeles Machine.
 - 3. C 136 - Standard Test Method for Sieve Analysis of Fine and Course Aggregates.
 - 4. D 422 - Standard Test Method for Particle-Size Analysis of Soils.
 - 5. D 2419 - Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate.
 - 6. D 2844 - Standard Test Method for Resistance R-Value and Expansion Pressure of Compacted Soils.
 - 7. D 4318 - Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
 - 8. D 4829 - Standard Test Method for Expansion Index for Soils.
 - 9. D 5821 - Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate.
- B. California Department of Transportation:
 - 1. Standard Specifications.
 - 2. California Test 205.
 - 3. California Test 211.
 - 4. California Test 217.
 - 5. California Test 229.
 - 6. California Test 301.

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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

- A. General:
 - 1. 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.
 - 2. Materials derived from processing demolished or removed asphalt concrete are not acceptable.
- B. Aggregate Base Course:
 - 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.
 - a. Aggregate base course for structures:
 - b. Consist of crushed or fragmented particles.
 - c. 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.
 - 2. Aggregate shall not be treated with lime, cement, or other chemical material.
 - 3. Durability index: Not less than 35 when tested in accordance with California Test 229.
 - 4. 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.
 - 5. Sand equivalent: Not less than 25 when tested in accordance with California Test 217.
 - 6. Resistance (R value): Not less than 78 when tested in accordance with California Test 301.
 - 7. Conform to size and grade within the limits as follows when tested in accordance with ASTM C 117 and ASTM C 136:

Sieve Sizes (Square Openings)	Percent by Weight Passing Sieve
1 inch	100
3/4 inch	90-100
Number 4	35-60
Number 30	10-30
Number 200	2-9

C. Class 2 Permeable:

1. Consist of hard, durable particles of stone or gravel, screened or crushed to the specified size and gradation.
2. Provide free of organic matter, lumps or balls of clay, and other deleterious matter.
3. Sand equivalent: Not less than 75 when tested in accordance with ASTM D 2419.
4. Conform to size and grade within the limits as follows when tested in accordance with ASTM C 117 and C 136:

Sieve Size (Square Openings)	Percent by Weight Passing Sieve
1 inch	100
3/4 inch	90-100
3/8 inch	40-100
Number 4	25-40
Number 8	18-33
Number 30	5-15
Number 50	0-7
Number 200	0-3

D. Drain Rock:

1. Durability: Percentage of wear not greater than 40 percent when tested in accordance with ASTM C 131.
2. Consist of hard, durable particles of stone or gravel, screened or crushed to specified size and gradation.
3. Free from organic matter, lumps or balls of clay, or other deleterious matter.
4. Crush or waste coarse material and waste fine material as required to meet gradation requirements.

5. Conform to size and grade within the limits as follows when tested in accordance with ASTM C 117 and C 136:

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

E. Native material:

1. Sound, earthen material passing 1 inch sieve.
2. Percent of material by weight passing Number 200 sieve shall not exceed 30 when tested in accordance with ASTM D 422.
3. Expansion index less than 35 when tested in accordance with ASTM D 4829.

F. Sand:

1. Clean, coarse, natural sand.
2. Non-plastic when tested in accordance with ASTM D 4318.
3. One hundred percent shall pass a 1/2 inch screen.
4. No more than 20 percent shall pass a Number 200 sieve.

G. Select material:

1. Sound earthen material for which sum of plasticity index when tested in accordance with ASTM D 4318 and the percent of material by weight passing Number 200 sieve shall not exceed 23 when tested in accordance with ASTM D 422.
2. Organic content shall not be greater than 3 percent by volume.

H. Stabilization material:

1. Durability percentage of wear not greater than 40 percent when tested in accordance with California Test 211.
2. Consist of clean, hard, durable particles of crushed rock or gravel screened or crushed to the specified sizes and gradations.
3. Shall be free of any detrimental quantity of soft, friable, thin, elongated, or laminated pieces, disintegrated material, organic matter, oil, alkali, or other deleterious substance.
4. Shall be free of slaking or decomposition under the action of alternate wetting and drying.
5. The portion of material retained on the 3/8 inch sieve shall contain at least 50 percent of particles having three 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 No. 4 sieve, not more than 10 percent shall be pieces that show no faces resulting from crushing.

6. Conform to size and grade when tested in accordance with ASTM C 117 and ASTM C 136.

Sieve Size (Square Openings)	Percent by Weight Passing Sieve
1 inch	100
3/4 inch	90-100
Number 4	0-10
Number 200	0-2

2.02 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 02100
SITE PREPARATION

PART 1 GENERAL

1.01 DESCRIPTION

- A. This Section specifies site preparation which consists of clearing, grubbing and demolition.

1.02 JOB CONDITIONS

- A. Existing Conditions
 - 1. The CONTRACTOR shall determine the actual condition of the Site as it affects this portion of work.
- B. Protection
 - 1. Site preparation shall not damage structures, landscaping or vegetation adjacent to the Site. The CONTRACTOR shall repair or replace any damaged property.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

- A. The CONTRACTOR shall notify the CONSTRUCTION MANAGER when site preparation is complete.

3.02 PERFORMANCE

- A. Clearing and Grubbing
 - 1. Unless otherwise specified, the CONTRACTOR shall remove obstructions such as brush, trees, logs, stumps, roots, heavy sod, vegetation, rock, stones larger than 6 inches in any dimension, broken or old concrete and pavement, debris, and structures where the completion of the work require their removal.
 - 2. Material that is removed and is not to be incorporated in the work shall be disposed of off the Site.
- B. Demolition and Removal
 - 1. Structures
 - a. Demolition and removal of structures consist of removal of abandoned superstructures, foundation walls, footings, slabs and any other structures. Excavations caused by existing foundations shall be cleared of waste, debris and loose soil, and refilled as specified.

2. Pavement
 - a. When portions of asphalt pavements and concrete pads are to be removed and later construction is to be connected, edges shall be saw cut, on a neat line at right angles to the curb face.
3. Salvage
 - a. The DISTRICT has the right to salvage any items scheduled for removal. The CONTRACTOR shall notify the CONSTRUCTION MANAGER 5 days prior to any salvage or demolition work to determine the disposition of items to be removed. The CONSTRUCTION MANAGER will mark items to be salvaged. Such items shall be properly disconnected, removed from their foundations, cleaned, and stored at a location on the Site as specified.
4. Excess Earthwork Materials
 - a. Excess clean surplus excavated materials and grading materials may be disposed of at a location that will be identified by the TRIBE and approved by the CONSTRUCTION MANAGER. The distance between the project site and the disposal location shall not exceed two miles. The CONTRACTOR shall be responsible for notifying the CONSTRUCTION MANAGER a minimum of two weeks in advance if the CONTRACTOR is interested in implementing this option. Materials testing and erosion control measures will be required prior to approval. The potential availability of the location for the disposal of excess materials does not void the CONTRACTOR's responsibility for the materials as described in Paragraph 3.02.D, Disposal of Materials.

C. Utility Interference

1. The DISTRICT has endeavored to determine the existence of utilities at the site of the Work from the records of the owners of known utilities in the vicinity of the Work. The positions of these utilities as derived from such records are shown on the Drawings. No excavations were made to verify the locations shown for underground utilities. The service connections to these utilities are not shown on the Drawings. It shall be the responsibility of the CONTRACTOR to determine the exact location of utilities and service connections thereto. The CONTRACTOR shall make his own investigations, including exploratory excavations, to determine the locations and type of existing utilities, including service connections, prior to commencing work which could result in damage to such utilities. The CONTRACTOR shall immediately notify the CONSTRUCTION MANAGER as to any utility discovered by him in a different position than shown on the Drawings or which is not shown on the Drawings.
2. In case it should be necessary to remove, relocate, or temporarily maintain a utility because of interference with the Work, the work on the utility shall be performed and paid for as follows:
 - a. When it is necessary to remove, relocate, or temporarily maintain a service connection, the cost of which is not required to be borne by the owner thereof, the CONTRACTOR shall bear the expenses incidental to the work on the service connection. The work on the service connection shall be done in a manner satisfactory to the owner thereof; it being understood that the owner of the service connection has the option of doing such work with his own forces, or permitting the work to be done by the CONTRACTOR.
 - b. When it is necessary to remove, relocate, or temporarily maintain a utility which is in the position shown on the Drawings, the cost of which is not required to

be borne by the owner thereof, the CONTRACTOR shall bear the expenses incidental to the work on the utility. The work on the utility shall be done in a manner satisfactory to the owner thereof; it being understood that the owner of the utility has the option of doing such work with his own forces, or permitting the work to be done by the CONTRACTOR.

- c. When it is necessary to remove, relocate, or temporarily maintain a utility which is not shown on the Drawings or is in a position different from that shown on the Drawings and were it in the position shown on the Drawings would not need to be removed, relocated, or temporarily maintained, the cost of which is not required to be borne by the owner thereof, the DISTRICT will make arrangements with the owner of the utility for such work to be done at no cost to the CONTRACTOR, or will require the CONTRACTOR to do such work in accordance with the article on changes in the work or will make changes in the alignment and grade of the work to obviate the necessity to remove, relocate, or temporarily maintain the utility.
- d. No representations are made that the obligations to move or temporarily maintain the utility and to pay the cost thereof is or is not required to be borne by the owner of such utility, and it shall be the responsibility of the CONTRACTOR to investigate to find out whether or not said cost is required to be borne by the owner of the utility.
- e. The right is reserved to governmental agencies and to owners of utilities to enter upon streets, alleys, rights-of-way, or easements for the purpose of making changes in their property made necessary by the Work and for the purpose of maintaining and making repairs to their property.

D. Disposal of Materials

- 1. All materials removed shall become the property of the CONTRACTOR unless designated by the CONSTRUCTION MANAGER and shall be removed from the project site. CONTRACTOR shall make his own arrangements for disposing of materials outside the project site, unless approved otherwise by the CONSTRUCTION MANAGER, and the CONTRACTOR shall pay all costs involved. Arrangements shall include, but not be limited to, entering into agreements with property owners and obtaining necessary permits, licenses and environmental clearances.

END OF SECTION

SECTION 02200

SITE CLEARING

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Clearing, grubbing, and stripping project site.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the CONTRACTOR'S responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR'S Work.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01354 - Hazardous Material Procedures.
 - b. Section 02050 - Soils and Aggregates for Earthwork.

1.02 REFERENCES (NOT USED)

1.03 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.
- C. Stripping: Includes the removal and disposal of all organic sod, topsoil, grass and grass roots, and other objectionable material remaining after clearing and grubbing from the areas designated to be stripped. The depth of stripping is estimated to be 6 inches, but the required depth of stripping will be determined by the ENGINEER.

1.04 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 and method of work.

1.05 PROJECT CONDITIONS

- A. Environmental requirements:
 - 1. For suspected hazardous materials found, as specified in Section 01354 Hazardous Material Procedures.
- B. Existing conditions:
 - 1. Verify character and amount of clay, sand, gravel, quicksand, water, rock, hardpan, and other material involved and work to be performed.

1.06 SEQUENCING AND SCHEDULING

- A. Clearing and grubbing: Perform clearing and grubbing in advance of grading operations.

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. Install fence at drip line of trees to remain as indicated on the Drawings.

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 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. Backfill and compact cavities left below subgrade elevation by removal of stumps or roots to density of adjacent undisturbed soil.
- C. Stripping:
1. Remove soil material containing sod, grass, or other vegetation to depth of 6 inches from areas to receive fill or pavement and from area within 5 feet outside foundation walls.
 2. Deposit stripped material in accordance with following requirements:
 - a. At locations as accepted.
 - b. Use accepted material in top 6 inches of areas to be used for future planting.
 3. Replace topsoil where indicated on the Drawings.
- D. Special Techniques (Not Used)

END OF SECTION

SECTION 02240

DEWATERING

PART 1 GENERAL

1.01 SUMMARY

- A. Scope
 - 1. Installation and maintenance of dewatering systems.
 - 2. Disposal of water entering excavation or other parts of the work.

1.02 SYSTEM DESCRIPTION

- A. The CONTRACTOR shall furnish, install, operate, and maintain all machinery, appliances, and equipment to maintain all excavations free from water during construction, and shall dewater and dispose of the water so as not to cause injury to public or private property, or to cause a nuisance or menace to the public.
- B. The dewatering system shall be installed and operated so that the groundwater level outside the excavation is not reduced to the extent which would cause damage or endanger adjacent structures.
- C. The static water level shall be drawn down a minimum of 3 feet below the bottom of the excavation in order to maintain the undisturbed state of the foundation soils and to facilitate the placement of fill or backfill compacted to the required density.

1.03 SUBMITTALS

- A. Dewatering plan:
 - 1. Dewatering design analysis.
 - 2. Estimated flow of dewatering discharge for all phases of the work.
 - 3. Required permits.
 - 4. Arrangement, location, and depths of dewatering system components.
 - 5. Type and sizes of filters.
 - 6. Identify proposed alignment, support, and protection for discharge pipe.
 - 7. 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. Flowmeter:

1. Product information on flowmeter and chart recorder.
 2. Recent flowmeter calibration documentation.
 3. Chart(s) from flowmeter chart recorder.
- D. Qualifications
1. Dewatering contractor.
 2. Dewatering design engineer.
 3. Testing laboratory.
- E. Control points and schedule of measurements:
1. The CONTRACTOR shall install 3 settlement monitoring control points around the perimeter of all excavations requiring dewatering.
 2. Location and details of control points and method and schedule of measurements.
 3. Within 24 hours of constructing control points, survey and submit measurements at each control point. Submit copy of field notes with measurements.
 4. Survey and submit measurements of control points every 7 days and submit measurements within 24 hours. For each control point:
 - a. Show current measurement and the change in measurement from first measurement taken.
 - b. Show graphical plot of movements.

1.04 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 5 years' experience in designing similar systems.
- B. Submit qualifications of dewatering contractor, dewatering design engineer, sampling service, and testing laboratory.
- C. The CONTRACTOR is responsible for obtaining all necessary permits and approvals for the proper disposal of the water.

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.
 3. Dewatering systems shall not be shut down between shifts, on holidays, on weekends, or during work stoppages.
- D. Monitoring wells:
1. At each excavation, a sufficient number of temporary observation wells to continuously check the groundwater level shall be provided. Locate monitoring wells within 6 feet of excavation and mid-way between dewatering wells or well points. The final locations of the monitoring wells shall be reviewed and approved by the ENGINEER 30 days before installation.
 2. The CONTRACTOR shall record and report the groundwater elevation reading to the ENGINEER two (2) times per week.
 3. Provide temporary threaded cap, not less than 2 inches in diameter, at the top of each well.
 4. Protect dewatering wells in place during excavation.
 5. One hundred percent standby pumping capacity shall be available on site at all times and shall be connected to the dewatering system piping to permit immediate use. In addition, standby ancillary equipment and appliances for all ordinary emergencies, and competent workmen for operation and maintenance of all dewatering equipment shall be on site at all times. Standby equipment shall include emergency power generation and automatic switchover to the emergency generator when normal power fails.
- E. The CONTRACTOR shall control surface water to prevent entry into excavations. Use dikes, curb walls, ditches, pipes, sumps, or other means acceptable to ENGINEER.
- F. Release of Groundwater
1. Prior to release of groundwater to its static level, confirm that all groundwater pressure relief devices for structure are fully operational, construction of structure is complete and concrete has reached its specified compressive strength, and backfill of structure is complete.
 2. The release of groundwater at its static level shall be performed in such a manner as to maintain the undisturbed state of the natural foundation soils, prevent disturbance of compacted backfill, and prevent flotation or movement of structures, pipelines and sewers.
 3. Water shall be de-sanded before disposal to any sewer or storm drain system. The system used for de-sanding water shall be a baffled structure and shall provide not less than five minutes detention time and shall be designed to have a flow-through velocity not exceeding 0.2 feet per second at the anticipated peak flow. The de-sanding box shall be cleaned as required to maintain the detention time and flow-through limitations specified above.
 4. The CONTRACTOR is responsible for disposing of dewatering in accordance with all local, state, and federal laws and regulations and for obtaining any necessary permits.

G. Dewatering Flow

1. A flowmeter and continuous 24-hour chart recorder for recording dewatering flow shall be provided.
2. Flowmeter and recorder device shall be calibrated to provide an accuracy within 5 percent.
3. Written evidence of calibration of flowmeter and recorded shall be provided.
4. Flow readings shall be submitted to the ENGINEER on a weekly basis.

END OF SECTION

SECTION 02300

EARTHWORK

PART 1 GENERAL

1.01 DESCRIPTION

- A. This Section specifies earthwork which consists of excavation, trenching, backfilling, grading and excess material control.

1.02 DEFINITIONS

- A. Compaction
 - 1. The degree of compaction is specified as percent compaction. Maximum or relative densities refer to dry soil densities obtainable at optimum moisture content.
- B. Excavation Slope
 - 1. Excavation slope shall be defined as an inclined surface formed by removing material from below existing grade.
- C. Embankment Slope
 - 1. Embankment slope shall be defined as an inclined surface formed by placement of material above existing grade.

1.03 QUALITY ASSURANCE

- A. Related Sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the CONTRACTOR'S responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR'S Work.
- B. References
 - 1. This Section references the following documents. They are a part of this Section insofar as specified and modified herein. In case of conflict between the requirements of this Section and the listed documents, the requirements of this Section shall prevail.

<u>Reference</u>	<u>Title</u>
AASHTO T176-80	Plastic Fines in Graded Aggregates and Soils by use of the Sand Equivalent Test
ASTM C136-06	Method of Test for Sieve or Screen Analysis of Fine and Coarse Aggregates

<u>Reference</u>	<u>Title</u>
ASTM D1556-07	Method of Test for Density of Soil in Place by the Sand-Cone Method and Nuclear Density Method
ASTM D6938-10	Method of Test for Moisture Content of Soil and Soil Aggregates in Place by Nuclear Methods (Shallow depth)

C. Tests

1. The CONTRACTOR shall contact the CONSTRUCTION INSPECTOR for the Project 48 hours prior to test, to schedule a third-party inspection and testing lab to perform the following tests on all imported materials from each source and native materials intended for backfill/bedding.
2. The CONTRACTOR shall remove surface material at locations designated by the CONSTRUCTION MANAGER and provide such assistance as necessary for testing. The CONTRACTOR shall employ the services of an independent testing laboratory, subject to approval by the CONSTRUCTION MANAGER, to sample and perform all required tests (moisture content, gradation, moisture-density relationships) on each type of material used. Tests shall be repeated on backfill material each time the source and/or characteristics change. The CONTRACTOR is responsible for all testing.
3. Backfill materials shall be tested in accordance with the following:

<u>Test</u>	<u>Standard Procedure</u>	<u>Test Frequency</u>
Moisture Content	ASTM D3017	Every 1000 s.f. of fill area (per compacted layer)
Gradation	ASTM C136	Each material source
Density In-Place	ASTM D1556	Every 1000 s.f. of fill area (per compacted layer)
Moisture-Density Relations	ASTM D6938	Each material source

D. Submittals

1. All submittals shall be made in accordance with Section 01330 Submittal Procedures.
2. Sample backfill material with corresponding test reports shall be submitted directly to the CONSTRUCTION MANAGER from the testing laboratory a minimum of 10 days prior to beginning work utilizing the backfill material. Samples shall consist of 0.5 cubic feet of each type of material.
3. Five copies and one original of the reports of the tests specified herein shall be submitted to the CONSTRUCTION MANAGER.

PART 2 PRODUCTS

2.01 FILL MATERIALS

A. Type A

1. Type A material shall be a clean gravel-sand mixture free from organic matter and shall conform to the following gradation:

<u>U.S. Standard Sieve Size</u>	<u>Percent by Weight Passing</u>
3/4 inch	100
3/8 inch	70-100
No. 4	55-100
No. 10	35- 95
No. 20	20- 80
No. 40	10- 55
No. 100	0-2

B. Type B

1. Type B material shall be a select granular material free from organic matter and of such size and gradation that the specified compaction can be readily attained.
2. Material shall have a sand equivalent value of not less than 20 and shall conform to the following gradation:

<u>U.S. Standard Sieve Size</u>	<u>Percent by Weight Passing</u>
1 inch	100
No. 4	35-100
No. 30	20-100

3. The coefficient of uniformity shall be 3 or greater.
4. The material may be an imported quarry waste, clean natural sand or gravel, select trench excavation or a mixture thereof.

C. Type C

1. Type C material shall be unclassified material and may be obtained from excavation on-site. The material shall be free from peat, wood, roots, bark, debris, garbage, rubbish or other extraneous material. The maximum size of stone shall not exceed 3 inches.

D. Type D

1. Type D material shall be granular material commonly known as pea gravel and shall conform to the following gradation:

<u>U.S. Standard Sieve Size</u>	<u>Percent by Weight Passing</u>
1/4 inch	100

No. 8

0-5

2. Type D material shall not be used for pipeline bedding, initial backfill or subsequent backfill.

E. Type E

1. Type E material shall be crushed rock commonly known as drain rock and shall conform to the following gradation:

<u>U.S. Standard Sieve Size</u>	<u>Percent by Weight Passing</u>
1 inch	100
3/4 inch	30-75
1/2 inch	15-55
1/4 inch	0-5

2. Type E material shall be composed of hard, durable, sound pieces having a specific gravity of not less than 2.65.

F. Type F

1. Type F material shall be crushed rock and shall conform to the following gradation:

<u>U.S. Standard Sieve Size</u>	<u>Percent by Weight Passing</u>
1 inch	87-100
3/4 inch	45-90
No. 4	20-50
No. 30	6-29
No. 200	0-12

2. Type F material shall be composed of hard, durable, sound pieces having a specific gravity of not less than 2.65.

G. Type G

1. Type G material shall be pervious backfill. Pervious backfill material (sand), shall conform to the following gradation:

<u>U.S. Standard Sieve Size</u>	<u>Percent by Weight Passing</u>
No. 50	100
No. 100	0-8
No. 200	0-4

H. Type H

1. Type H material shall be 6-inch riprap. Riprap shall be graded rock having a range of individual rock weights as follows:

<u>Weight of Stone</u>	<u>Percent smaller by weight</u>
10 pounds	100
5 pounds	80-100
2 pounds	45-80
1 pound	15-45
.5 pound	5-15
Below .5 pound	0-5

2. Specific gravity shall be between 2.5 and 2.82.

I. Type I

1. Type I material shall be unclassified material but may be obtained from excavation on-site. The material may contain extraneous material, such as demolition waste, unsuitable material excavated from beneath structures, and clearing and grubbing debris up to 50 percent by volume. Extraneous material shall be thoroughly mixed and the maximum size of organic particles shall be 6 inches.

J. Type J

1. Type J material shall be crushed rock used for gravel roadways and shall have the following gradation:

<u>U.S. Standard Sieve Size</u>	<u>Percent by Weight Passing</u>
3/4 inch	100
3/8 inch	61-90
No. 4	42-58
No. 16	17-31
No. 50	9-21
No. 200	4- 8

2. Type J material shall be composed of hard, durable, sound pieces having a specific gravity of not less than 2.65.

PART 3 EXECUTION

3.01 GENERAL

A. Control of Water

1. The CONTRACTOR shall keep excavations reasonably free from water during construction. The static water level shall be drawn down a minimum of one foot below the bottom of excavations to maintain the undisturbed state of natural soils and allow the placement of any backfill to the specified density. Disposal of water shall not damage property, create a public nuisance or violate the law. The CONTRACTOR shall have on hand pumping equipment and machinery in good working condition for emergencies and shall have workmen available for its

operation. Dewatering systems shall operate continuously until backfill has been completed to one foot above the normal static groundwater level.

2. Groundwater shall be controlled to prevent softening of the bottom of excavations or formation of "quick" conditions. Dewatering systems shall not remove natural soils.
 3. Release of groundwater to its static level shall be controlled to prevent disturbance of the natural foundation soils or compacted backfill and to prevent flotation or movement of structures or pipelines.
 4. Additional requirements and suggested methods of control of water and dewatering shall be in accordance with Section 02240 Dewatering.
- B. Overexcavation
1. Where undisturbed condition of natural soils is inadequate for support of the planned construction as determined by the CONSTRUCTION MANAGER, the CONSTRUCTION MANAGER will direct the CONTRACTOR to overexcavate to adequate supporting soils. The excavated space shall be filled to the specified elevation with backfill. The quantity and placement of such material will be paid for as extra work.
- C. Surplus Material
1. Unless otherwise specified, clean surplus excavated material shall be legally disposed of off-site by the CONTRACTOR. Hauling and disposal operations shall be conducted in accordance with applicable ordinances and environmental requirements. The CONTRACTOR may dispose of clean surplus excavated materials at a location that will be identified by the TRIBE and approved by the CONSTRUCTION MANAGER. The distance between the project site and the disposal location shall not exceed two miles. The CONTRACTOR shall be responsible for notifying the CONSTRUCTION MANAGER a minimum of two weeks in advance if the CONTRACTOR is interested in implementing this option. Materials testing and erosion control measures will be required prior to approval.
 2. Rubbish and non-clean surplus excavated material, as determined by the CONSTRUCTION MANAGER, shall be legally disposed of off-site by the CONTRACTOR.
 3. Material shall not be stockpiled to a depth greater than 5 feet above finished grade within 25 feet of any excavation. The CONTRACTOR shall maintain stability of the soil adjacent to any excavation.
 4. If the quantity of surplus material is specified, the quantity specified is approximate. Shortage of material, caused by premature disposal of any material by the CONTRACTOR, shall be replaced by the CONTRACTOR.
- D. Hauling
1. When hauling is done over highways or city streets, the loads shall be trimmed, and the vehicle shelf areas shall be cleaned after each loading. The loads shall be watered after trimming to eliminate dust.
- E. Finish Grading
1. Finished surfaces shall be smooth, compacted and free from irregularities. The degree of finish shall be that normally obtainable with a blade-grader.

2. Finished grade shall be as specified by the contours plus or minus 0.10 foot except where a local change in elevation is required to match sidewalks, curbs, manholes and catch basins, or to ensure proper drainage. Allowance for topsoil, grass cover and gravel, and subbase and pavement thickness shall be made so that the specified thickness of topsoil can be applied to attain the finished grade.
3. When the work is at an intermediate stage of completion, the lines and grades shall be as specified plus or minus 0.5 foot to provide adequate drainage.

F. Control of Erosion

1. The CONTRACTOR shall maintain earthwork surfaces true and smooth and protected from erosion. Where erosion occurs, the CONTRACTOR shall provide fill or shall excavate as necessary to return earthwork surfaces to the grade and finish specified.

G. Buried Utilities

1. Buried utilities may be encased in concrete. The CONTRACTOR shall plan for this and incorporate associated costs into the bid pricing.

3.02 CLASSIFICATION OF BACKFILL

- A. Backfill material shall be provided and placed in horizontal layers and compacted with power operated tampers, rollers, idlers, or vibratory equipment. Material type, maximum layer depth, relative compaction, and general application are specified in Table A. Unless otherwise specified, backfill classes shall be used where specified in Table A under general application.

Table A, Fill Classification

Fill Class	Material Type	Maximum Uncompressed Layer Depth, Inches	Minimum Relative Compaction, Percent	General Application
A1	A	8	95	Initial and subsequent pipeline backfill
B1	B	8	95	Pipe bedding zone
C1	C	8	95	Native backfill zone
E1 ^a	E	8	95	Drain rock
F1	F	12	95	Structure backfill

- B. Compaction of layers shall be accomplished in two passes of equipment with complete coverage across the width of the fill area.

3.03 EARTHWORK FOR STRUCTURES

A. Structure Excavation

1. Ground shall not be dug by open tooth machinery nearer than 3 inches from any finished subgrade. The last 3 inches shall be removed without disturbing the subgrade.
2. The bottom shall not be more than 0.15 foot above or below the lines and grades specified. If the elevation of structure excavation is not specified, the excavation shall be not more than 0.15 foot above or below the elevation specified for fill material below the structure. Slopes shall vary no more than 0.5 foot from specified grade unless the excavation is in rock where the maximum variation shall be 2 feet.
3. Should the excavation be carried below the lines and grades specified on the drawings or should the bottom of the excavation be disturbed because of the CONTRACTOR'S operations and require overexcavation and backfill, the CONTRACTOR shall refill such excavated space to the proper elevation in accordance with the procedure specified for backfill.
4. Unless otherwise specified, excavations shall extend a sufficient distance from walls and footings to allow for placing and removal of forms, installation of services, and for inspection, except where concrete is specified to be placed directly against excavated surfaces.

B. Foundation Treatment

1. Foundations for concrete or masonry footings shall be excavated to sound material. Sound material shall be imported as required.
2. When swell or subsidence results, the CONTRACTOR shall excavate, or backfill the footing area to the grade of the bottom of the footing with suitable material as specified. If material under footings is such that it would mix into the concrete during footing placement or would not support the weight of the fluid concrete, the CONTRACTOR shall replace the material with suitable material, install soffit forms or otherwise provide a suitable platform on which to cast the footing as directed by the CONSTRUCTION MANAGER. This shall not be paid for as extra work.
3. Whenever any structure excavation is substantially completed to grade, the CONTRACTOR shall notify the CONSTRUCTION MANAGER who will make an inspection of the foundation. No concrete or masonry shall be placed until the foundation has been inspected by the CONSTRUCTION MANAGER. The CONTRACTOR shall, if directed by the CONSTRUCTION MANAGER, dig test pits and make test borings and foundation bearing tests. If the material tested is undisturbed soil, the cost thereof will be paid for as extra work. If the material tested is backfill material, the cost thereof will be paid as extra work only if it meets all specified placement and compaction requirements.

C. Structure Backfilling

1. Unless otherwise specified, structure backfill shall be Class F1.
2. After completion of construction below the elevation of the final grade, and prior to backfilling, forms shall be removed, and the excavation shall be cleaned of debris.
3. Structure backfill shall not be placed until the subgrade portions of the structure have been inspected by the CONSTRUCTION MANAGER. No backfill material shall be deposited against concrete structures until the concrete has developed a strength of not less than 3,000 pounds per square inch in compression.

4. Backfill material shall be placed in uniform layers and shall be brought up uniformly on all sides of the structure. Compaction by ponding, flooding or jetting is not allowed.
5. If the compacted surface of any layer of material is too smooth to bond properly with the succeeding layer, the surface shall be scarified. If required, the surface shall be sprinkled, or otherwise moisture conditioned before the succeeding lift is placed. Any surface crust formed on a layer of fill material that has been dumped and spread shall be broken up by harrowing and, if required, the full depth of the affected layer shall be moisture conditioned immediately prior to rolling.
6. Unless otherwise specified, backfill around and above pipelines within the excavation line of any structure shall be the same as that specified for structures.

END OF SECTION

SECTION 02312

CONTROLLED LOW STRENGTH MATERIAL (CLSM)

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Controlled low strength material (CLSM).
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the CONTRACTOR'S responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR'S Work.
 - 3. The following sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 03300 - Cast-in-Place Concrete.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. C 31 - Standard Practice for Making and Curing Concrete Test Specimens in the Field.
 - 2. C 33 - Standard Specification for Concrete Aggregates.
 - 3. C 39 - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
 - 4. C 143 - Standard Test Method for Slump of Hydraulic Cement Concrete.
 - 5. C 231 - Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
 - 6. C 260 - Standard Specification for Air-Entraining Admixtures for Concrete.
 - 7. C 618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
 - 8. D 1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft³(2,700 kN-m/m³)).

1.03 SYSTEM DESCRIPTION

- A. Performance requirements:
 - 1. Total calculated air content: Not be less than 80 percent nor greater than 12.0 percent.
 - 2. Minimum unconfined compressive strength: Not less than 50 pounds per square inch measured at 28 days.

02312-1

3. Maximum unconfined compressive strength: Not greater than 150 pounds per square inch measured at 28 days.
4. Wet density: No greater than 132 pounds per cubic foot.

1.04 SUBMITTALS

- A. Product data: Submit data completely describing products.
- B. Sieve analysis: Submit sieve analyses of fine and coarse aggregates being used in triplicate. Resubmit at any time there is a significant change in grading of materials.
- C. Mix: Submit full details, including mix design calculations for mix proposed for use.
- D. Trial batch test data:
 1. Submit data for each test cylinder.
 2. Submit data that identifies mix and slump for each test cylinder.
- E. Cement mill tests: Include alkali content, representative of each shipment of cement for verification of compliance with specified requirements.
- F. Pozzolan certificate of compliance: Identify source of pozzolan and certify compliance with requirements of ASTM C 618.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Portland cement: Type II low alkali portland cement as specified in Section 03300 Cast-in-Place Concrete.
- B. Fly ash: Class F fly ash in accordance with ASTM C 618.
- C. Water: As specified in Section 03300 Cast-in-Place Concrete.
- D. Admixture: Air entraining admixture in accordance with ASTM C 260.
- E. Fine aggregate: Concrete sand that does not need to be in accordance with ASTM C 33. No more than 12 percent of fine aggregate shall pass a No. 200 sieve, and no plastic fines shall be present.
- F. Coarse aggregate: Pea gravel no larger than 3/8 inch.

2.02 MIXES

- A. Suggested design mix:

Material	Weight	Specific Gravity	Absolute Volume Cubic Foot
Cement	30 pounds	3.15	0.15
Fly Ash	300 pounds	2.30	2.09
Water	283 pounds	1.00	4.54
Coarse Aggregate	1,465 pounds	2.68	8.76
Fine Aggregate	1,465 pounds	2.68	8.76
Admixture	4-6 ounces	-	2.70
TOTAL	3,543 pounds	-	27.00

2.03 SOURCE QUALITY CONTROL

A. Trial batch:

1. After mix design has been accepted by ENGINEER, have trial batch of the accepted mix design prepared by testing laboratory acceptable to ENGINEER.
2. Prepare trial batches using specified cementitious materials and aggregates proposed to be used for the Work.
3. Prepare trial batch with sufficient quantity to determine slump, workability, consistency, and to provide sufficient test cylinders.

B. Test cylinders:

1. Prepare test cylinders in accordance with ASTM C 31 with the following exceptions:
 - a. Fill the concrete test cylinders to overflowing and tap sides lightly to settle the mix.
 - b. Do not rod the concrete mix.
 - c. Strike off the excess material.
2. Place test cylinders in a moist curing room. Exercise caution in moving and transporting the cylinders since they are fragile and will withstand only minimal bumping, banging, or jolting without damage.
3. Do not remove the test cylinder from mold until the cylinder is to be capped and tested.
4. The test cylinders may be capped with standard sulfur compound or neoprene pads:
 - a. Perform the capping carefully to prevent premature fractures.
 - b. Use neoprene pads a minimum of 1/2 inch thick, and 1/2 inch larger in diameter than the test cylinders.
 - c. Do not perform initial compression test until the cylinders reach a minimum age of 3 days.

- C. Compression test 8 test cylinders: Test 4 test cylinders at 3 days and 4 at 28 days in accordance with ASTM C 39 except as modified herein:

1. The compression strength of the 4 test cylinders tested at 28 days shall be equal to or greater than the minimum required compression strength, but shall not exceed maximum compression strength.
- D. If the trial batch tests do not meet the Specifications for strength or density, revise and resubmit the mix design, and prepare additional trial batch and tests. Repeat until an acceptable trial batch is produced that meets the Specifications.
 1. All the trial batches and acceptability of materials shall be paid by the CONTRACTOR.
 2. After acceptance, do not change the mix design without submitting a new mix design, trial batches, and test information.
- E. Determine slump in accordance with ASTM C 143 with the following exceptions:
 1. Do not rod the concrete material.
 2. Place material in slump cone in one semi-continuous filling operation, slightly overfill, tap lightly, strike off, and then measure and record slump.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Prior to placement, soils located below controlled low strength material placement shall be scarified to a depth of 8 inches, uniform moisture conditioned to or above the optimum moisture content, and compacted to a minimum of 95 percent relative compaction in accordance with ASTM D 1557.
- B. Place controlled low strength material by any method which preserves the quality of the material in terms of compressive strength and density:
 1. Limit lift heights of CLSM placed against structures and other facilities that could be damaged due to the pressure from the CLSM, to the lesser of 3 feet or the lift height indicated on the Drawings. Do not place another lift of CLSM until the last lift of CLSM has set and gained sufficient strength to prevent lateral load due to the weight of the next lift of CLSM.
 2. The basic requirement for placement equipment and placement methods is the maintenance of its fluid properties.
 3. Transport and place material so that it flows easily around, beneath, or through walls, pipes, conduits, or other structures.
 4. Use a slump of the placed material greater than 9 inches, and sufficient to allow the material to flow freely during placement:
 - a. After trial batch testing and acceptance, maintain slump developed during testing during construction at all times within plus or minus 1 inch.
 5. Use a slump, consistency, workability, flow characteristics, and pumpability (where required) such that when placed, the material is self-compacting, self-densifying, and has sufficient plasticity that compaction or mechanical vibration is not required.

3.02 FIELD QUALITY CONTROL

- A. General:

1. Make provisions for and furnish all material for the test specimens, and provide manual assistance to assist the ENGINEER in preparing said specimens.
 2. Be responsible for the care of and providing curing condition for the test specimens.
- B. Tests by DISTRICT:
1. During the progress of construction, the DISTRICT will have tests made to determine whether the controlled low strength material, as being produced, complies with the requirements specified hereinbefore. Test cylinders will be made and delivered to the laboratory by the ENGINEER and the testing expense will be borne by the DISTRICT.
 2. Test cylinders:
 - a. Prepare test cylinders in accordance with ASTM C 31 with the following exceptions:
 - 1) Fill the concrete test cylinders to overflowing and tap sides lightly to settle the mix.
 - 2) Do not rod the concrete mix.
 - 3) Strike off the excess material.
 - b. Place the cylinders in a safe location away from the construction activities. Keep the cylinders moist by covering with wet burlap, or equivalent. Do not sprinkle water directly on the cylinders.
 - c. After 2 days, place the cylinders in a protective container for transport to the laboratory for testing. The concrete test cylinders are fragile and shall be handled carefully. The container may be a box with a Styrofoam or similar lining that will limit the jarring and bumping of the cylinders.
 - d. Place test cylinders in a moist curing room. Exercise caution in moving and transporting the cylinders since they are fragile and will withstand only minimal bumping, banging, or jolting without damage.
 - e. Do not remove the test cylinder from mold until the cylinder is to be capped and tested.
 - f. The test cylinders may be capped with standard sulfur compound or neoprene pads:
 - 1) Perform the capping carefully to prevent premature fractures.
 - 2) Use neoprene pads a minimum of 1/2 inch thick, and 1/2 inch larger in diameter than the test cylinders.
 - 3) Do not perform initial compression test until the cylinders reach a minimum age of 3 days.
 3. Not less than 3 cylinder specimens will be tested for each 150 cubic yards of controlled low strength material and not less than 3 specimens for each half day's placement:
 - a. Test 1 cylinder at 3 days and 2 at 28 days in accordance with ASTM C 39 except as modified herein.
 - b. The compression strength of the cylinders tested at 28 days shall be equal to or greater than the minimum required compression strength, but shall not exceed maximum compression strength.
 4. The DISTRICT will test the air content of the controlled low strength material. Test will be made immediately after discharge from the mixer in accordance with ASTM C 231.

C. Tests by CONTRACTOR:

1. Test the slump of controlled low strength material using a slump cone in accordance with ASTM C 143 with the following exceptions:
 - a. Do not rod the concrete material.
 - b. Place material in slump cone in one semi-continuous filling operation, slightly overfill, tap lightly, strike off, and then measure and record slump.
2. Test the slump at the beginning of each placement, as often as necessary to keep the slump within the specified range, and when requested to do so by the ENGINEER.

END OF SECTION

SECTION 02318

TRENCHING

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Trench excavation, fine grading, pipe bedding, backfilling, and compaction for the following, including requirements for ditch crossings:
 - 1. Pipes.
 - 2. Direct buried electrical and control conduits.
 - 3. Electrical and control duct banks.
 - 4. Manholes, valves, or other accessories.
 - 5. Potable water pipe appurtenances.
- B. Related Sections
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the CONTRACTOR'S responsibility for scheduling and coordinating the work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR'S Work.
 - 3. The following sections are related to the work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 02240 - Dewatering.
 - b. Section 02300 - Earthwork.
 - c. Section 02312 - Controlled Low Strength Material (CLSM).
 - d. Section 15956 - Piping System Testing.

1.02 REFERENCES

- A. ASTM International (ASTM)
 - 1. D 1556 - Standard Test Method for Density and Unit Weight of Soil in Place by the Sand Cone Method.
 - 2. D 1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft³ (2,700 kN-m/m³)).
 - 3. D 2922 - Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
 - 4. D 3017 - Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).

1.03 SUBMITTALS

- A. All submittals shall be made in accordance with Section 01330 Submittal Procedures.

- B. Lab certification.
- C. Confirmation test reports.

1.04 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. 200 linear feet of trench backfill.
 - 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."

PART 2 PRODUCTS

2.01 MATERIALS

- A. Soil and rock materials
 - 1. Aggregate base course material: As specified in Section 02300 Earthwork.
 - 2. Gravel: As specified in Section 02300 Earthwork.
 - 3. Native material: As specified in Section 02300 Earthwork.
 - 4. Sand: As specified in Section 02300 Earthwork.
 - 5. Select material: As specified in Section 02300 Earthwork.
- B. Controlled low-strength material: As specified in Section 02312 Controlled Low Strength Material.

PART 3 EXECUTION

3.01 PREPARATION

- A. General
 - 1. Embankment condition
 - a. Exists where width of trench exceeds limits specified in this Section.
 - b. Before laying pipes in fill, place fill and compact it to not less than 2 feet above top of pipe.
 - c. After placing and compacting fill, excavate pipe trench through fill.
- B. Protection
 - 1. Stabilize trench excavations per standards.

3.02 INSTALLATION

- A. Trench Excavation

1. General Requirements
 - a. If, because of soil conditions, safety requirements, or other reasons, trench width at top of pipe is increased beyond width specified in this Section, upgrade laying conditions or install stronger pipe designed in conformance with Specifications for increased trench width, without additional cost to DISTRICT.
 - b. Excavate bottom of trench to depth indicated on the Drawings. The bottom of the trench excavation shall be firm and dry.
2. The trench may be excavated by machinery to the grade indicated on the Drawings provided that the soil material remaining in the bottom of the trench is no more than slightly disturbed.
3. Rock
 - a. Pipe
 - 1) If bottom of trench excavation is found to consist of rock or any material that by reason of its hardness cannot be excavated to provide uniform bearing surface, remove such rock or other material to a depth of not less than 4 inches below bottom of fine grading material. Backfill overcut with aggregate base course material compacted to 95 percent of maximum density up to bottom of fine grading material.
4. Overcut of trench bottom
 - a. Where the bottom of the trench is excavated below the depth indicated on the Drawings, restore trench bottom to proper grade by back filling with aggregate base course material compacted to 95 percent of maximum density, at no additional cost to DISTRICT.
5. Soft or unstable material
 - a. If bottom of excavation is found to consist of soft or unstable material which is incapable of providing proper support, remove such material to a depth and for the length required, as determined by the ENGINEER. Backfill trench to bottom of fine grading material with aggregate base course material compacted to 90 percent of maximum density.
6. Concrete cradle
 - a. Where indicated on the Drawings, cradle pipe in concrete.
7. Trench widths
 - a. Minimum clear width of trench for pipe (measured at top of pipe):
 - 1) For pipe sizes 4 inches to and including 24 inches: Not less than outside diameter of pipe plus 18 inches.
 - 2) For pipe sizes larger than 24 inches: Not less than outside diameter of pipe plus 24 inches.
 - b. Maximum clear width of trench for pipe (measured at top of pipe):
 - 1) For pipe sizes 4 inches to and including 24 inches: Not to exceed outside diameter of pipe plus 24 inches.
 - 2) For pipe sizes larger than 24 inches: Not to exceed outside diameter of pipe plus 36 inches.
8. For manholes, valves, or other accessories
 - a. Provide excavations sufficient to leave at least 12 inches clear between their outer surfaces and sides of trench or shoring.
 - b. Backfilling of manhole excavation: Conform to backfilling requirements as specified for trenches in this Section.

- c. Backfill under manholes, vaults, tanks, or valves with aggregate base course material. Do not backfill with soil.
 - d. Fill any unauthorized excess excavation below elevation indicated on the Drawings for foundation of any structure with aggregate base course material at no additional cost to the DISTRICT.
 - 9. Potable water pipe appurtenances
 - a. Lay in trenches separate from those used for sewers.
 - b. Unless otherwise specified or indicated on the Drawings, lay in trenches having cover of not less than 42 inches below surface of ground and located at distance of not less than 10 feet from any parallel sewer trench.
 - 10. At road crossings or existing driveways
 - a. Make provision for trench crossings at these points, either by means of backfills, tunnels, or temporary bridges.
- B. Dewatering
 - 1. As specified in Section 02240 Dewatering.
- C. Pipe fine grading
 - 1. Schedule fine grading material as specified in this Section.
 - 2. For pipes 16 inches in nominal diameter and under:
 - a. Place 4 inches of fine grading material below bottom of pipe.
 - b. Place fine grading material at uniform density, with minimum possible compaction.
 - 3. For pipe over 16 inches in diameter
 - a. Place 4 inches, or 1/12 the outside diameter of pipe, whichever is greater, of fine grading material below bottom of pipe.
 - b. Place fine grading material at uniform density, with minimum possible compaction.
 - 4. Bell or coupling holes
 - a. Dig holes after trench bottom has been graded.
 - b. Provide holes of sufficient width to provide ample room for grouting, banding, or welding.
 - c. Excavate holes only as necessary for making joints and to ensure that pipe rests upon prepared trench bottom and not supported by any portion of the joint.
 - 5. Depressions for joints, other than bell-and-spigot
 - a. Make in accordance with recommendations of joint manufacturer for particular joint used.
- D. Pipe bedding
 - 1. Schedule bedding material as specified in this Section.
 - 2. After pipe laid
 - a. Place bedding material under and around pipe in 6-inch maximum lifts of bedding material, to level 12 inches above top of pipe. Compact to 95 percent of maximum density.
 - 3. 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.
- E. Trench backfill above pipe bedding, electrical and control conduit bedding, and electrical and control ductbanks.
 - 1. Under structures
 - a. Backfill trench up to underside of structure with material as specified in Section 02300 Earthwork compacted to 95 percent of maximum density.
 - 2. Cuts across roadways and paved streets
 - a. Backfill trench to underside of pavement with material as specified in Section 02300 Earthwork compacted to 95 percent of maximum density.
 - 3. Under and parallel to roadways, paved areas, or storage areas
 - a. Backfill trench up to within 2 feet of finish grade with native material compacted to 95 percent of maximum density.
 - b. Then backfill from 2 feet below finish grade to finish grade, or underside of aggregate base course or pavement as indicated on the Drawings with aggregate base course material as specified in Section 02300 Earthwork, compacted to 95 percent of maximum density.
 - 4. In areas outside the improved section of roadways or in open country
 - a. Backfill to finish grade with native material as specified in Section 02300 Earthwork compacted to 90 percent of maximum density.
 - 5. Through earth slopes adjacent to, or supporting structures
 - a. Backfill to finish grade with select material compacted to 95 percent of maximum density.
- F. Under existing intersecting pipes or conduits larger than 3 inches in diameter
 - 1. Backfill from bottom of new pipe trench to spring line of intersecting pipe or conduit with controlled low-strength material as specified in Section 02312 Controlled Low Strength Material.
 - 2. Extend controlled low-strength material as specified in Section 02312 Controlled Low Strength Material two feet on either side of intersecting pipe or conduit to ensure that material remains in place while other backfill is being placed.
 - 3. Backfill remainder of trench as specified in "Trench backfill above pipe bedding and for conduits and duct banks" above.
- G. Compaction
 - 1. In-place density of compacted trench backfill, and bedding determined in accordance with ASTM D 1556, or with ASTM D 2922 and ASTM D 3017.
 - 2. Maximum density obtained in laboratory when tested in accordance with ASTM D 1557.
 - 3. Consolidation
 - a. Do not use water settling methods such as flooding, poling, or jetting.
- H. Excess material
 - 1. Remove excess excavated material from the Project site as specified in Section 02300 Earthwork and dispose of legally off-site.

3.03 FIELD QUALITY CONTROL

A. Tests

1. Confirmation tests

a. CONTRACTOR'S responsibilities

- 1) Accomplish specified compaction of trench backfill.
- 2) Control operations by confirmation tests to verify and confirm that compaction work complies, and is complying at all times, with requirements specified in this Section concerning compaction, control, and testing.
- 3) Cost of confirmation tests: Paid for by the CONTRACTOR.
- 4) Qualifications of CONTRACTOR'S testing laboratory: Acceptable to ENGINEER. Provide lab certification.
- 5) Copies of confirmation test reports: Submit promptly to the ENGINEER.

b. Frequency of confirmation testing

- 1) Perform testing not less than as follows
 - a) For trenches: At each test location include tests for each type or class of backfill from bedding to finish grade.
 - b) In open fields: 2 every 1,000 linear feet.
 - c) Along dirt or gravel road or off traveled right-of-way: 2 every 500 linear feet.
 - d) Crossing paved roads: 2 locations along each crossing.
 - e) Under pavement cuts or within 2 feet of pavement edges: 1 location every 400 linear feet.

2. Compliance tests

- a. Frequency of testing: Periodic compliance tests will be made by the ENGINEER to verify that compaction is meeting requirements previously specified.
- b. If compaction fails to meet specified requirements: Perform remedial work by one of the following methods:
 - 1) Remove and replace backfill at proper density.
 - 2) Bring density up to specified level by other means acceptable to the ENGINEER.

3. Retesting

- a. Costs of retesting: CONTRACTOR is responsible for the costs of retesting required to confirm and verify that remedial work has brought compaction within specified requirements.
- b. CONTRACTOR'S confirmation tests during performance of remedial work:
 - 1) Performance: Perform tests in manner acceptable to the ENGINEER.
 - 2) Frequency: Double amount specified for initial confirmation tests.

B. Piping system testing

1. As specified in Section 15956 Piping Systems Testing.

3.04 SCHEDULES

A. Pipe fine grading materials

1. Fine grading material shall be the same as bedding material.
- B. Bedding materials
1. Pipes
 - a. For pipe less than 16-inch nominal size: Except as otherwise specified, use sand or aggregate base course material.
 - b. For pipe from 16- inch to 48-inch nominal size: Except as otherwise specified, use sand or aggregate base course material.
 - c. For pipe over 48 inches: Aggregate base course material.
 - d. For polyvinyl chloride or other plastic pipe less than 2 inches in diameter: Sand.
 2. Direct buried electrical and control conduits: Sand.

END OF SECTION

SECTION 02722
CRUSHED AGGREGATE BASE COURSE

PART 1 GENERAL

1.01 SUMMARY

- A. Section Includes: Furnishing, placing and compacting crushed aggregate on a prepared surface.

1.02 SUBMITTALS

- A. General: Submittals shall be according to Section 01330 Submittal Procedures.
- B. Test Data: Submit three (3) copies of test data for the CONTRACTOR furnished aggregate to be used on this Project.
- C. Certificates of Conformance: Submit three (3) copies of written certification from the supplier of the CONTRACTOR-furnished aggregate to be used on this Project that it conforms to the requirements of this Specification Section.

1.03 DELIVERY, STORAGE AND HANDLING

- A. Delivery: Mitigate spillage or damage that occurs during delivery.

1.04 PROJECT/SITE CONDITIONS

- A. Excess Materials: Shall be removed from the site.

1.05 WARRANTY

- A. Requirements: Aggregate base found to be defective within 12 months after work completion, shall be replaced at the CONTRACTOR'S expense. Overlaying material that must be replaced because of defective base material shall also be replaced at the CONTRACTOR'S expense.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Crushed Aggregate: Furnish hard, durable particles or fragments of crushed stone or gravel conforming to the size and quality requirements for crushed aggregate material normally used locally in construction and maintenance of highways by federal or state agencies. Furnish crushed aggregate with a maximum size of 1 inch as determined by AASHTO T27 and T11. Furnish crushed aggregate uniformly

graded from coarse to fine and free of organic matter, lumps or balls of clay and other deleterious matter.

PART 3 EXECUTION

3.01 INSTALLATION

- A. General: The material shall be placed on the prepared surface and compacted in layers of the thickness shown on the drawings. When more than one layer is required, each layer shall be shaped and compacted before the succeeding layer is placed.
 - 1. Placing shall be from vehicles equipped to distribute the material in a continuous uniform layer or windrow. The layer or windrow shall be of such size that when spread and compacted, the finished layer shall have the required thickness.
 - 2. When hauling is done over previously placed material, hauling equipment shall be routed uniformly as possible over the entire surface of the constructed layers.
- B. Spreading: When uniformly mixed, the mixture shall be spread smoothly for compaction to the required thickness.
- C. Compacting: Immediately following final spreading and smoothing, each layer shall be compacted to the full width by approved compaction equipment. Rolling shall progress gradually from the sides to the center, parallel to the centerline of the road, or parking area, and shall continue until the surface has been rolled. Irregularities or depressions that develop shall be corrected by loosening the material at these places. Add or remove material until the surface is smooth and uniform. Along curbs and at places not accessible to the roller, the base material shall be compacted thoroughly with approved tampers or compactors.
- D. Watering: Provide water and watering equipment to control dust and obtain required compaction.

3.02 FIELD QUALITY CONTROL

- A. Testing: Testing shall be conducted in the presence of the Contracting Officer who shall be given 48 hour notice before a test is to be conducted. The CONTRACTOR shall make arrangements for a certified independent testing laboratory, according to the requirements of Section 01458 Testing and Testing Laboratory Services, to perform the required testing, recording, and distributing of the results.
- B. Density:
 - 1. Compaction of each layer shall continue until a density of not less than 100 percent of the maximum density determined according to AASHTO T 180 Method D, or other method approved in writing by the Contracting Officer, has been achieved.
 - 2. In-place field density determinations are made according to AASHTO T 191, AASHTO T 205, or other approved method. The use of AASHTO T 224 to correct for oversize particles may be required.

3. Test holes are made at random during the work to determine the depth of uncompacted layers required to produce the designated depth of material after compacting to the specified density.
 4. Cutting of the test holes and refilling with materials properly compacted shall be done by the CONTRACTOR and approved in writing by the Contracting Officer.
- C. Completed Course Thickness: Shall not vary more than 1/2-inch from the thickness required.
- D. Surface: Shall be tested for acceptance by the CONTRACTOR with a 10-foot straight edge after the base has been bladed and rolled into a smooth surface. Areas where the surface variation exceeds 1/2-inch in 10 feet shall be reworked until the variation falls within this limit.

3.03 PROTECTION

- A. Traffic Control: The CONTRACTOR shall provide the controls to prevent unauthorized traffic in or on work areas until those areas are suitably prepared for traffic.

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.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the CONTRACTOR'S responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR'S Work.
 - 3. The following sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 02722 - Crushed Aggregate Base Course.
 - b. Section 03150 - Concrete Accessories.
 - c. Section 03300 - Cast-In-Place Concrete.
 - d. Section 03366 - Tooled Concrete Finishes.

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.

1.04 PROJECT CONDITIONS

- A. Do not use curing compound where solvents in the curing compounds are prohibited by state or federal air quality laws. Use only water curing methods.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Concrete: Class A, as specified in Section 03300 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.
 - 2. Construction: Steel dividers or plastic inserts.

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 02722 Crushed Aggregate Base Course.
 - 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. Special techniques:
 - 1. CONTRACTOR'S option:
 - a. Construct concrete curbs and gutters by conventional use of forms, or by means of curb and gutter machine when acceptable to the ENGINEER.
 - b. When use of machines designed specifically for work of this Section are accepted by the ENGINEER, results must be equal to or better than those produced by use of forms.
 - c. Applicable requirements of construction that apply to use of forms also apply to use of machines.
 - d. Discontinue use of machines when results are not satisfactory to the ENGINEER.

- B. 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.
- C. Expansion and contraction 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 adjoining structures.
 - c. Fill joints with expansion joint filler material.
 - 2. Weakened-plane joints:
 - a. Constructed as indicated on the Drawings.
 - b. Make joints of construction joint material, scoring or saw cutting to depth of not less than 1-1/2 inches and matching joints in adjacent pavement or sidewalk.
- D. 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 Finishes 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.
 - e. Driveways and door pads: Broom finish.
- E. 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. Gutters:
- c. 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.
- d. Test method: Establish flow in length of gutter to be tested by supplying water from hydrant, tank truck, or other source.
- e. 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 two (2) joints.

END OF SECTION

SECTION 03055

EPOXY BONDING 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 epoxy adhesive.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the CONTRACTOR'S responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR'S Work.
 - 3. The following sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
 - a. Division 1 - General Conditions.
 - b. Section 01410 - Regulatory Requirements.
 - c. Section 03301 - Concrete Work.
 - d. Section 05120 - Structural Steel.

1.02 REFERENCES

- A. American National Standards Institute (ANSI):
 - 1. Standard B212.15 - Carbide Tipped Masonry Drills and Blanks for Carbide Tipped Masonry Drills.
- B. ASTM International (ASTM):
 - 1. C 881 - Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete.
- C. ICC Evaluation Service, Inc. (ICC-ES):
 - 1. AC308 - Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements.
- D. Society for Protective Coatings (SSPC):
 - 1. Surface Preparation Standards (SP)
 - a. SP-1 - Solvent Cleaning.

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1.03 SUBMITTALS

- A. Product data: Furnish technical data for epoxy adhesives, including:
 - 1. Installation instructions.
 - 2. Independent laboratory test results.
 - 3. Handling and storage instructions.
- B. Quality control submittals:
 - 1. Epoxy manufacturer's past project experience data on at least three (3) similar projects supplied with proposed products within the last three (3) years.
 - 2. Special inspection: Provide detailed step-by-step instructions for the special inspection procedure in accordance with the building code as specified in Section 01410 Regulatory Requirements.
 - 3. ICC Evaluation Service, Inc., Evaluation Services Report in compliance with the AC308-Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements.

1.04 DELIVERY, STORAGE, AND HANDLING

- A. Storage and protection.
 - 1. Store epoxy components on pallets or shelving in a covered-storage area.
 - 2. Control temperature above 60 degrees Fahrenheit and dispose of product if shelf life has expired.
 - 3. If stored at temperatures below 60 degrees Fahrenheit, test components prior to use to determine if they still meet specified requirements.

1.05 PROJECT CONDITIONS

- A. Seismic design category: D.

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.

2.02 EPOXY ADHESIVE FOR SELF-CONTAINED CARTRIDGE SYSTEM

- A. Epoxy adhesive shall have a current ICC Evaluation Service report documenting acceptance under AC308 for use with cracked concrete and for the seismic design categories specified.
- B. Materials
 - 1. In accordance with ASTM C 881, Type IV, Grade 3, Class B or C depending on site conditions.
 - 2. 2-component, 100 percent solids, insensitive to moisture, and gray in color.
 - 3. Cure temperature, pot life, and workability: Compatible with intended use and environmental conditions.

C. Packaging

1. Furnished in side-by-side cartridges with resin and hardener components isolated until mixing through manufacturer's static mixing nozzle. Nozzle designed to thoroughly blend the components for injection from the nozzle directly into prepared hole.
2. Container markings: Include manufacturer's name, product name, batch number, mix ratio by volume, product expiration date, ANSI hazard classification, and appropriate ANSI handling precautions.

D. Manufacturers: One of the following or equal:

1. Hilti, Inc., Tulsa, OK: RE 500-SD.
2. Simpson Strong-Tie Company, Inc., Pleasanton, CA: SET-XP.

2.03 ALL THREAD RODS

- A. Materials: As specified in Section 05120 Structural Steel.

2.04 REINFORCING BARS

- A. As specified in Section 03301 Concrete Work.

PART 3 EXECUTION

3.01 GENERAL

A. Provide epoxy adhesive packaged as follows:

1. Disposable, self-contained cartridge system capable of dispensing both epoxy components in the proper mixing ratio, and fit into a manually or pneumatically operated caulking gun.
2. Dispense components through a mixing nozzle that thoroughly mixes components.

3.02 HOLE SIZING AND INSTALLATION

A. Drilling holes:

1. Determine location of reinforcing bars or other obstructions with a non-destructive 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 acceptance by ENGINEER.

B. Hole drilling equipment:

1. Electric or pneumatic rotary impact type with medium or light impact.
2. Drill bits: Carbide-tipped in accordance with ANSI B212 15.
3. 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.
4. Where edge distances are less than 2 inches, use lighter impact equipment to prevent microcracking and concrete spalling during drilling process.

- C. Hole diameter: Reinforcing bar diameter or all thread rod diameter plus 1/8 inch.

- D. Obstructions in drill path:
1. If an existing reinforcing bar or other obstruction is hit while drilling hole, stop drilling hole and fill the hole with drypack mortar. Relocate the hole to miss the obstruction and drill another hole. Repeat the above until the hole has been drilled to the required depth.
 2. Avoid drilling an excessive number of holes in an area of a structural member, which would excessively weaken the structural member and endanger the stability of the structure. Drypack holes which hit obstructions and allow drypack to reach strength equal to the existing concrete before drilling adjacent holes. Epoxy grout may be substituted for drypack when acceptable to ENGINEER.
 3. When existing reinforcing steel is encountered during drilling and when acceptable to 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.
 4. Bent bar reinforcing bars: Where edge distances are critical, and striking reinforcing steel is likely, and if acceptable to ENGINEER, drill hole at 10 degree angle or less from axis of reinforcing bar or all thread rod being installed.
- E. Install reinforcing bars and all thread rods to depth, spacings, and locations as indicated on the Drawings.
1. Do not install epoxy bonded all-thread rods or reinforcing bars in overhead applications.
- F. Cleaning holes:
1. Insert long air nozzle into hole and blow out loose dust. Use compressed air that is free of oil, water, or other contaminants that will reduce bond.
 2. Use a stiff bristle brush to vigorously brush hole to dislodge compacted drilling dust.
 3. Repeat step 1.
 4. Repeat above steps as required to remove drilling dust or other material that will reduce bond. The hole shall be clean and dry.
- G. Cleaning reinforcing bars and all thread rods:
1. Solvent clean reinforcing bar and all thread rods over the embedment length in accordance with SSPC SP-1 Solvent Cleaning. Provide an oil and grease free surface to promote bonding of adhesive to steel.
 2. Clean reinforcing bars and all thread rods over embedment length to bare metal. The reinforcing bars and all thread rods shall be free of oil, grease, paint, dirt, mill scale, rust, or other coatings that will reduce bond.
- H. Filling hole with epoxy:
1. Fill hole with epoxy before inserting the reinforcing bar or all thread rod. Fill hole with epoxy starting from bottom of hole. Fill hole without creating air voids.
 2. Fill hole with sufficient epoxy so that excess epoxy is extruded out of the hole when the reinforcing bar or all thread rod is inserted into the hole.
 3. Do not install epoxy prior to receiving epoxy manufacturer's onsite training.

3.03 MANUFACTURERS' SERVICES

- A. Furnish manufacturer's representative to conduct jobsite training for proper installation, handling, and storage of epoxy, for personnel who will perform actual installation. ENGINEER may attend training sessions.

END OF SECTION

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SECTION 03071

EPOXIES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Epoxy.
 - 2. Epoxy gel.
 - 3. Epoxy bonding agent.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the CONTRACTOR'S responsibility for scheduling and coordinating the work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR'S Work.
 - 3. The following sections are related to the work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed work complies accurately with the Contract Documents.
 - a. Section 03072 - Epoxy Resin/Portland Cement Bonding Agent.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. D 638 - Standard Test Method for Tensile Properties of Plastics.
 - 2. D 695 - Standard Test Method for Compressive Properties of Rigid Plastics.
 - 3. D 790 - Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.

1.03 SYSTEM DESCRIPTION

- A. Performance requirements:
 - 1. Provide epoxy materials that are new and use them within shelf life limitations set forth by manufacturer.
 - 2. Perform and conduct work of this Section in neat orderly manner.

1.04 SUBMITTALS

- A. Product Data: Submit manufacturer's data completely describing epoxy materials.
- B. Quality control submittals:
 - 1. Manufacturer's installation instructions.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Epoxy: Water-insensitive 2-part type low viscosity epoxy adhesive material containing 100 percent solids and meeting or exceeding following characteristics when tested in accordance with standards specified: Manufacturers: One of the following or equal:
1. BASF, MBT, Concresive® Standard LVI.
 2. Sika Chemical Corp., Sikadur 35 Hi-Mod LV.

Physical Characteristic	Test Method	Required Results
Tensile Strength	ASTM D 638	8,000 pounds per square inch minimum at 14 days and 77 degrees Fahrenheit cure.
Flexure Strength	ASTM D 790	11,000 pounds per square inch minimum at 14 days and 77 degrees Fahrenheit cure.
Compressive Strength	ASTM D 695	16,000 pounds per square inch minimum at 24 hours and 77 degrees Fahrenheit cure.
Bond Strength	--	Concrete shall fail before failure of epoxy.
Gel Time for 5 Mil Film	--	4 hours maximum at 77 degrees Fahrenheit.
Elongation	ASTM D 638	1 percent minimum at 14 days and 77 degrees Fahrenheit.

- B. Epoxy gel: Manufacturers: The following or equal:
1. Sika Chemical Corp., Sikadur 31, Hi-Mod Gel.
- C. Epoxy bonding agent: Manufacturers: One of the following or equal:
1. BASF, MBT, Concresive® Liquid LPL.
 2. Sika Chemical Corp., Sikadur 32, Hi-Mod LPL.
 3. If increased tack 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.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the CONTRACTOR'S responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR'S Work.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. C 109 - Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2 inch or [50 mm] Cube Specimens).
 - 2. C 348 - Standard Test Method for Flexural Strength of Hydraulic-Cement Mortars.
 - 3. C 496 - Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens.
 - 4. C 882 - Standard Test Method for Bond Strength of Epoxy-Resin Systems Used With Concrete by Slant Shear.
- B. Federal Highway Administration (FHWA):
 - 1. FHWA-RD-86-193 - Highway Concrete Pavement Technology Development and Testing Volume V: Field Evaluation of SHRP C9206 Test Sites (Bridge Deck Overlays).

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Sika Corporation, Lyndhurst, New Jersey, 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 proved 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 C 109:
 - a. 1 day: 810 pounds per square-inch minimum.
 - b. 7 days: 6,000 pounds per square-inch minimum.
 - c. 28 days: 8,000 pounds per square-inch minimum.
 2. Splitting tensile strength in accordance with ASTM C 496:
 - a. 28 days: 540 pounds per square-inch minimum.
 3. Flexural strength:
 - a. 1,100 pounds per square-inch minimum in accordance with ASTM C 348.
 4. Bond strength in accordance with ASTM C 882 modified at 14 days:
 - a. 0 hours open time: 1,900 pounds per square-inch minimum.
 - b. 24 hours open time: 1,500 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/RD86/193. 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 that quantity that can be applied within its pot life.

- B. Placement procedure:
 - 1. Apply to prepared surface with stiff-bristle brush, broom, or "hopper type" spray equipment:
 - a. For hand applications: Place fresh, plastic concrete/mortar while the bonding bridge adhesive is wet or dry, up to 24 hours.
 - b. For machine applications: Allow the bonding bridge adhesive to dry for 12 hours minimum.
- C. Adhere to all limitations and cautions for the epoxy resin / portland cement adhesive in the manufacturer's current printed literature.

3.02 CLEANING

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

END OF SECTION

SECTION 03102

CONCRETE FORMWORK

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Concrete formwork.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the CONTRACTOR'S responsibility for scheduling and coordinating the work of subcontractor, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR'S Work.
 - 3. The following sections are related to the work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed work complies accurately with the Contract Documents.
 - a. Section 03300 - Cast-in-Place Concrete.
 - b. Section 03600 - Grouting.
 - c. Section 07900 - Joint Sealants.

1.02 REFERENCES

- A. American Concrete Institute (ACI):
 - 1. 117 - Specifications for Tolerances for Concrete Construction and Materials and Commentary.
- B. NSF International (NSF):
 - 1. 61 - Drinking Water System Components - Health Effects.
- C. Underwriters Laboratories (UL).

1.03 DEFINITIONS

- A. Green concrete: Concrete with less than 100 percent of the minimum specified compressive strength f'_c .

1.04 SYSTEM DESCRIPTION

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

2. Design forms and ties to withstand concrete pressures without bulging, spreading, or lifting of forms.
- B. Performance requirements:
1. Construct forms so that finished concrete conforms to shapes, lines, grades, and dimensions indicated on the Drawings.
 2. It is intended that surface of concrete after stripping presents smooth, hard, and dense finish that requires minimum amount of finishing.
 3. Provide sufficient number of forms so that the work may be performed rapidly and present uniform appearance in form patterns and finish.
 4. Use forms that are clean and free from dirt, concrete, and other debris.
 - a. Coat with acceptable form release agent if required, prior to use or reuse.

1.05 SUBMITTALS

- A. Information on the CONTRACTOR'S proposed forming system:
1. Submit in such detail as the ENGINEER may require to assure himself that intent of the Specifications can be complied with by use of proposed system.
 2. Alternate combinations of plywood thickness and stud spacing: May be submitted.
- B. Form release agent. Confirmation of certification for conformance to NSF 61.

1.06 PROJECT CONDITIONS

- A. Do not remove forms from concrete which has been placed when outside ambient air temperature is below 50 degrees Fahrenheit until concrete has attained specified strength as determined by test cylinders stored in field under equivalent conditions as concrete structure.

PART 2 PRODUCTS

2.01 MANUFACTURED UNITS

- A. Form ties:
1. General:
 - a. Provide form ties for forming system selected that are manufactured by recognized manufacturer of concrete forming equipment.
 - b. Do not use wire ties or wood spreaders of any form.
 - c. Provide ties of type that accurately tie, lock, and spread forms.
 - d. Provide form ties of such design that when forms are removed, they locate no metal or other material within 1-1/2-inches of the surface of the concrete.
 - e. Do not allow holes in forms for ties to allow leakage during placement of concrete.
 2. Cone-snap ties:
 - a. Cone-snap ties shall form a cone shaped depression in the concrete with a minimum diameter of 1-inch at the surface of the concrete and 1 1/2-inches deep.

- b. Provide neoprene waterseal washer that is located near the center of the concrete.
 - 3. Taper ties:
 - a. Neoprene plugs for taper tie holes: Size so that after they are driven, plugs are located in center third of wall thickness.
- B. Built-up plywood forms:
 - 1. Built-up plywood forms may be substituted for prefabricated forming system subject to following minimum requirements:
 - a. Size and material:
 - 1) Full size 4- foot by 8-foot plywood sheets, except where smaller pieces are able to cover entire area.
 - 2) Sheet construction: 5-ply plywood sheets, 3/4-inch nominal, made with 100 percent waterproof adhesive, and having finish surface that is coated or overlaid with surface which is impervious to water and alkaline calcium and sodium hydroxide of cement.
 - b. Wales: Minimum 2-inch by 4-inch lumber.
 - c. Studding and wales: Contain no loose knots and be free of warps, cups, and bows.
- C. Steel or steel framed forms:
 - 1. Steel forms: Provide forms that are:
 - a. Rigidly constructed and capable of being braced for minimum deflection of finish surface.
 - b. Capable of providing finish surfaces that are flat without bows, cups, or dents.
 - 2. Steel framed plywood forms:
 - a. Provide forms that are rigidly constructed and capable of being braced.
 - b. Plywood paneling: 5-ply, 5/8-inch nominal or 3/4-inch nominal, made with 100 percent waterproof adhesive, and having finish surface that is coated or overlaid with surface which is impervious to water and alkaline calcium and sodium hydroxide of cement.
- D. Form release agent.
 - 1. Effective, non-staining, bond-breaking coating compatible with form surfaces and concrete mixes used.
 - 2. Certified for conformance to NSF 61 and leaving no taste or odor on the concrete surface.
 - a. Submit NSF 61 certification prepared by NSF, UL, or other similar nationally recognized testing laboratory acceptable to the ENGINEER.
- E. Incidentals:
 - 1. External angles:
 - a. Where not otherwise indicated on the Drawings, provide with 3/4-inch bevel, formed by utilizing true dimensioned wood or solid plastic chamfer strip on walkways, slabs, walls, beams, columns, and openings.
 - b. Provide 1/4-inch bevel formed by utilizing true dimensioned wood or solid plastic chamfer strip on walkways, walls, and slabs at expansion and construction joints.

2. Keyways: Steel, plastic, or lumber treated with form release oil, applied according to label directions.

PART 3 EXECUTION

3.01 EXAMINATION

A. Site verification of conditions:

1. Do not place any concrete until all forms have been thoroughly checked for alignment, level, strength, and to assure accurate location of all mechanical and electrical inserts or other embedded items.

3.02 INSTALLATION

A. Forms and accessories:

1. Vertical forms:

- a. Remain in place minimum of 24 hours after concrete is placed.
- b. If, after 24 hours, concrete has sufficient strength and hardness to resist surface or other damage, forms may be removed.

2. Other forms supporting concrete and shoring: Remain in place as follows:

- a. Sides of footings: 24 hours minimum.
- b. Vertical sides of beams, girders, and similar members: 48 hours minimum.
- c. Bottom of slabs, beams, and girders: Until concrete strength reaches specified strength $f'c$ or until shoring is installed.
- d. Shoring for slabs, beams, and girders: Shore until concrete strength reaches specified strength.
- e. Wall bracing: Brace walls until concrete strength of beams and slabs laterally supporting wall reaches specified strength.

3. Green concrete:

- a. No heavy loading on green concrete will be permitted.

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

B. Form ties:

1. Cone-snap ties: Tie forms together at not more than 2-foot centers vertically and horizontally. After forms are removed from wall, fill tie holes as follows:

- a. Remove form ties from surfaces.
- b. Roughen cone shaped tie holes by heavy sandblasting before repair.
- c. Dry pack cone shaped tie holes with dry-pack mortar as specified in Section 03600 Grouting.

2. Taper ties:

- a. After forms and taper ties are removed from wall, plug tie holes with neoprene plug as follows:

- 1) Heavy sandblast and then clean tie holes.
- 2) After cleaning, drive neoprene plug into each of taper tie holes with steel rod. Final location of neoprene plug shall be in center third of wall thickness. Bond neoprene plug to concrete with epoxy.

- 3) Locate steel rod in cylindrical recess, made in plug, during driving.
 - a) At no time are plugs to be driven on flat area outside cylindrical recess.
 - b. Dry-pack of taper tie holes: After installing plugs in tie holes:
 - 1) Coat tie hole surface with epoxy bonding agent and fill with dry-pack mortar as specified in Section 03600 Grouting.
 - 2) Place dry-pack mortar in holes in layers with thickness not exceeding tie hole diameter and heavily compact each layer.
 - 3) Dry-pack the outside of the hole no sooner than 7 days after the inside of the hole has been dry packed.
 - 4) Wall surfaces in area of dry-packed tie holes: On the water side of water containing structures and the outside of below grade walls:
 - 5) Cover with minimum of 10 mils of epoxy gel.
 - c. Provide epoxy gel coating on wall surfaces that extend minimum of 2-inches past dry-pack mortar filled tie holes.
 - d. Provide finish surfaces that are free from sand streaks or other voids.
- C. Built-up plywood forms:
1. Studding:
 - a. Spaced at 16-inches or 24-inches on center.
 - b. Closer spacing may be required depending upon strength requirements of the forms, in order to prevent any bulging surfaces on faces of finished concrete work.
 - c. Install studs perpendicular to grain of exterior plys of plywood sheets.
 2. Wales: Form wales of double lumber material with minimum size as specified in this Section.
 3. Number of form reuses: Depends upon durability of surface coating or overlay used, and ability to maintain forms in condition such that they are capable of producing flat, smooth, hard, dense finish on concrete when stripped.
- D. Steel or steel framed forms:
1. Steel forms:
 - a. Adequately brace forms for minimum deflection of finish surface.
 2. Steel framed plywood forms:
 - a. Rigidly construct and brace with joints fitting closely and smoothly.
 - b. Number of form reuses: Depends upon durability of surface coating or overlay used.
 3. Built-up plywood forms: As specified in this Section may be used in conjunction with steel forms or steel framed plywood forms for special forming conditions such as corbels and forming around items which will project through forms.
- E. Bracing and alignment of forms:
1. Line and grade: Limit deviations to tolerances which will permit proper installation of structural embedded items or mechanical and electrical equipment and piping.
 2. Formwork:
 - a. Securely brace, support, tie down, or otherwise hold in place to prevent movement.
 - b. Make adequate provisions for uplift pressure, lateral pressure on forms, and deflection of forms.

3. When second lift is placed on hardened concrete: Take special precautions in form work at top of old lift and bottom of new lift to prevent:
 - a. Spreading and vertical or horizontal displacement of forms.
 - b. Grout "bleeding" on finish concrete surfaces.
 4. Pipe stubs, anchor bolts, and other embedded items: Set in forms where required.
 5. Cracks, openings, or offsets at joints in formwork: Close those that are 1/16-inch or larger by tightening forms or by filling with acceptable crack filler.
- F. Incidentals:
1. Keyways: Construct as indicated on the Drawings.
 2. Reentrant angles: May be left square.
 3. Level strips: Install at top of wall concrete placements to maintain true line at horizontal construction joints.
 4. Inserts:
 - a. Encase pipes, anchor bolts, steps, reglets, castings, and other inserts, as indicated on the Drawings or as required, in concrete.
- G. Pipe and conduit:
1. Install pipe and conduit in structures as indicated on the Drawings, and seal with materials as specified in Section 07900 Joint Sealants.

3.03 CONSTRUCTION

- A. Tolerances:
1. Finish concrete shall conform to shapes, lines, grades, and dimensions indicated on the Drawings.
 2. The maximum deviation from true line and grade shall not exceed tolerances listed below at time of acceptance of project.
 3. In accordance with ACI 117, paragraphs 2.1 through 2.2 and paragraphs 4.0 through 4.6, except as modified in following:
 - a. Slabs:
 - 1) Slope: Uniformly sloped to drain when slope is indicated on the Drawings.
 - 2) Slabs indicated to be level: Have maximum deviation of 1/8-inch in 10-feet without any apparent changes in grade.
 - b. On circular tank walls: The CONTRACTOR may deviate from finish line indicated on the Drawings by use of forms with chord lengths not to exceed 2-feet.
 - c. Inserts: Set inserts to tolerances required for proper installation and operation of equipment or systems to which insert pertains.
 - d. Maximum tolerances: As follows:

Item	Tolerance
Sleeves and Inserts	Plus 1/8 Minus 1/8 inches
Projected Ends of Anchor Bolts	Plus 1/4 Minus 0.0 inches

Item	Tolerance
Anchor Bolt Setting	Plus 1/16 Minus 1/16 inches

END OF SECTION

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SECTION 03150
CONCRETE ACCESSORIES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Polyvinyl chloride waterstop.
 - 2. Preformed synthetic sponge rubber expansion joint material.
 - 3. Preformed bituminous fiber expansion joint material.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. D 570 - Standard Test Method for Water Absorption of Plastics.
 - 2. D 624 - Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers.
 - 3. D 638 - Standard Test Method for Tensile Properties of Plastics.
 - 4. D 746 - Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact.
 - 5. D 747 - Standard Test Method for Apparent Bending Modulus of Plastics by Means of a Cantilever Beam.
 - 6. D 792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
 - 7. D 2240 - Standard Test Method for Rubber Property – Durometer Hardness.
- B. 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 requirements of current 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: Shall be free of misalignment, bubbles, inadequate bond, porosity, cracks, offsets, and other defects which would reduce the potential resistance of the material to water pressure at any point. Replace defective joints. Remove faulty material from the site and disposed of by the CONTRACTOR at its own expense.
- C. Inspections:
 1. Quality of welded joints will be subject to acceptance of the ENGINEER.
 2. Polyvinyl chloride waterstop: The following defects that represent a 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 the material thickness, at any point, whichever is less.
 - c. Any combination of offset or crack which will result in a net reduction in the cross section of the waterstop in excess of 1/16-inch or 15 percent of the material thickness, at any point, whichever is less.
 - d. Misalignment of the joint, which will result in misalignment of the waterstop in excess of 1/2-inch in 10-feet.
 - e. Porosity in the welded joint as evidenced by visual inspection.
 - f. Bubbles or inadequate bonding.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Polyvinyl chloride waterstops: Manufactured from prime virgin polyvinyl chloride plastic compound containing the plasticizers, resins, stabilizers, and other materials necessary to meet the requirements of this Section. No scrap or reclaimed material shall be used.

2.02 MANUFACTURED UNITS

A. Waterstops:

1. Polyvinyl chloride waterstops:

a. Manufacturers: One of the following or equal:

- 1) Vinylex Corporation, Kwik-Tie.
- 2) Greenstreak Plastic Products Company, Inc.

b. Type: Ribbed waterstop:

- 1) Construction joints: 6-inch wide ribbed type.
- 2) Expansion joint for wall penetrations for concrete encased electrical duct banks: 6-inch ribbed type with hollow center bulb.
- 3) Expansion joints: 9-inch wide ribbed type with hollow center bulb.

c. Provide polyvinyl chloride waterstops complying with following requirements:

Physical Characteristics	Test Method	Required Results
Specific Gravity	ASTM D 792	Not less than 1.3.
Hardness	ASTM D 2240	70 to 90 Type A Shore durometer.
Tensile Strength	ASTM D 638	Not less than 2,000 pounds per square inch.
Ultimate Elongation	ASTM D 638	Not less than 350 percent
Alkali Extraction	CRD-C-572	7 day weight change between minus 0.1 percent and plus 0.25 percent.
Low Temperature Brittle Point	ASTM D 746	Not more than minus 35 degrees Fahrenheit.
Water Absorption	ASTM D 570	Not more than 0.15 percent after 24 hours.
Accelerated Extraction Tensile	CRD-C-572	Not less than 2,000 pounds per square inch.
Stiffness in Flexure	ASTM D 747	Not less than 725 pounds per square inch.
Tear Resistance	ASTM D 624	Not less than 300 pounds per inch.
Weight Requirements		
6-inch Waterstops	—	Weigh not less than 130 pounds per 100 linear feet.
9-inch Waterstops	—	Weigh not less than 220 pounds per 100 linear feet.
Thickness	—	3/8 inch

Physical Characteristics	Test Method	Required Results
Center Bulb		
6-inch Waterstops	–	7/8 inch or 1 inch nominal outside diameter.
9-inch Waterstops	–	1 inch nominal outside diameter. For expansion joints 1 inch and narrower and 2 inches for expansion joints wider than 1 inch.
Allowable Tolerances		
Width	–	Plus or minus 3/16 inch.
Thickness	–	Plus or minus 1/32 inch.

- d. Dumbbell type waterstop will not be allowed unless otherwise specified or indicated on the Drawings.

Physical Characteristics	Test Method	Required Results
Minimum Ultimate Tensile Strength	ASTM A 370	75,000 pounds per square inch
Elongation in 2-inch Minimum	ASTM A 370	40 percent
Rockwell B Hardness	ASTM A 370	95 maximum
Minimum Yield Strength	ASTM A 370	25,000 pounds per square inch

- B. Preformed expansion joint materials:
1. Preformed synthetic sponge rubber expansion joint material:
 - a. Manufacturers: One of the following or equal:
 - 1) Tamms Industries, Inc., Cementone.
 - 2) Burke Concrete Accessories Inc., Neoprene Sponge Rubber Expansion Joint.
 2. Preformed bituminous fiber expansion joint material:
 - a. Manufacturers: One of the following or equal:
 - 1) Tamms Industries, Inc., Hornboard/fiber.
 - 2) Burke Concrete Accessories Inc., Fiber Expansion Joint.
 3. Use specific type in applications as indicated on the Drawings.
 4. No scrap or recycled material shall be used.

PART 3 EXECUTION

3.01 INSTALLATION

A. Waterstops - General:

1. Waterstops shall be stored so as to permit free circulation of air around the waterstop material and to prevent direct exposure to sunlight.
2. Install waterstops in concrete joints where indicated on the Drawings.
3. Carry waterstops in walls into lower slabs and join to waterstops in slabs with appropriate types of fittings.
4. In waterbearing structures: Provide all joints with waterstops, whether indicated on the Drawings or not.
5. Provide waterstops that are continuous.
6. Set waterstops accurately to position and line as indicated on the Drawings.
7. 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.
8. Position the waterstop so that symmetrical halves of the waterstop are equally divided between the concrete pours. The center axis of the waterstop shall be coincident with the centerline of the joint.
9. Do not drive nails, screws, or other fasteners through waterstops in vicinity of construction joints.
10. Use wires at not more than 24-inches on centers near outer edge of the waterstop to tie waterstops into position.
11. Special clips may be used in lieu of wires, at CONTRACTOR'S option.
12. Terminate waterstops 3-inches from top of finish surfaces of walls and slabs unless otherwise specified or indicated on the Drawings.
13. When any waterstop is installed in the concrete on one side of a joint, while the other half or portion of the waterstop remains exposed to the atmosphere for more than 2 days, suitable precautions shall be taken to shade and protect the exposed waterstop from direct rays of sunlight during the entire exposure and until the exposed portion is embedded in concrete.
14. When placing concrete at waterstops in slabs, lift the edge of the waterstop while placing concrete below the waterstop. Manually force the waterstop against and into the concrete. Then cover the waterstop with fresh concrete.

B. Polyvinyl chloride waterstops:

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

4. All joints with waterstops involving more than 2 ends to be joined together, and all joints that involve an angle cut, alignment change, or the joining of 2 dissimilar waterstop sections shall be prefabricated by the CONTRACTOR or the manufacturer prior to placement in the forms, providing not less than 24-inch long strips of waterstop material beyond the joint. Upon being inspected and accepted, install such prefabricated waterstop joint assemblies in the forms and the ends of the 24-inch strips shall be butt welded to the straight run portions of waterstop in place in the forms.
 5. Vertical crosses and tees shall be factory prefabricated by the manufacturer. Horizontal crosses or tees may be field or factory welded.
 6. Split type waterstop will not be permitted except where specifically indicated on the Drawings.
- C. Joints:
1. Construct construction and expansion joints as indicated on the Drawings.
 2. Preformed expansion joint material: Fasten expansion joint strips to concrete, masonry, or forms with adhesive. No nailing will be permitted, nor shall expansion joint strips be placed without fastening.

END OF SECTION

SECTION 03200

CONCRETE REINFORCING

PART 1 GENERAL

1.01 SUMMARY

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

1.02 REFERENCES

- A. American Concrete Institute (ACI):
 - 1. 315 - Details and Detailing of Concrete Reinforcement.
 - 2. 318 - Building Code Requirements for Structural Concrete and Commentary.
 - 3. 350 - Code Requirements for Environmental Engineering Concrete Structures and Commentary.
- B. American Welding Society (AWS):
 - 1. D1.4 - Structural Welding Code - Reinforcing Steel.
- C. ASTM International (ASTM):
 - 1. A 185 - Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete.
 - 2. A 615 - Standard Specification for Deformed and Plain Carbon Steel Bars for Concrete Reinforcement.
 - 3. A 706 - Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement.

1.03 DEFINITIONS

- A. Give away bars: Bars that are not required by Contract Documents, but are installed by the CONTRACTOR to support the required reinforcing bars.

1.04 SYSTEM DESCRIPTION

- A. The Drawings contain general notes concerning amount of reinforcement and placing, details of reinforcement at wall corners and intersections, and details of extra reinforcement around openings in concrete.

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1.05 SUBMITTALS

- A. Shop drawings:
 - 1. Changes to reinforcing steel contract drawing requirements:
 - 2. Indicate in separate letter submitted with shop drawings any changes of requirements indicated on the Drawings for reinforcing steel.
 - 3. Such changes will not be acceptable unless the ENGINEER has accepted such changes in writing.
- B. Reinforcement shop drawings:
 - 1. Review of reinforcement shop drawings by the ENGINEER will be limited to general compliance with the Contract Documents.
 - 2. Submit reinforcement shop drawings in a complete package for each specific structure. Partial submittals will be rejected.
- C. Samples:
 - 1. Bar support chairs: Submit samples of chairs proposed for use along with letter stating where each type of chair will be used.
- D. Procedures:
 - 1. Welding procedures conforming to AWS D1.4 for reinforcement designated to be field welded.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Packing and shipping:
 - 1. Deliver bars bundled and tagged with identifying tags.
- B. Acceptance at site:
 - 1. Reinforcing bars: Deliver reinforcing bars lacking grade identification marks accompanied by manufacturer's guarantee of grade.

1.07 SEQUENCING AND SCHEDULING

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

PART 2 PRODUCTS

2.01 MATERIALS

- A. Bar supports:
 - 1. Wire bar supports located between reinforcing bars and face of concrete:
 - a. Stainless steel. Type 304 stainless steel bar supports.
 - b. Support reinforcing for concrete placed on ground using bar support chairs with Type 304 stainless steel plates for resting on ground welded to the chairs.
 - 2. Wire bar supports located between mats of reinforcing bar:
 - a. Steel bar supports.

- B. Reinforcing bars:
 - 1. Reinforcing bars to be embedded in concrete:
 - a. ASTM A 615 Grade 60 deformed bars, except as follows.
 - 2. Reinforcing bars that are required to be welded:
 - a. Low alloy ASTM A 706 Grade 60 deformed bars.
 - b. ASTM A 615 Grade 60 reinforcement may be used in lieu of ASTM A 706 Grade 60 if the following requirements are satisfied.
 - 1) Welding procedures conforming to AWS D1.4 are submitted to the ENGINEER.
 - 2) The specific location for the proposed substitution is acceptable to the ENGINEER.
- C. Tie wires: Annealed steel.
- D. Welded wire fabric reinforcement:
 - 1. In accordance with ASTM A 185.
 - 2. Fabric may be used in place of reinforcing bars if accepted by the ENGINEER.
 - 3. Provide welded wire fabric in flat sheet form.
 - 4. Provide welded wire fabric having cross-sectional area per linear foot of not less than cross-sectional area per linear foot of reinforcing bars indicated on the Drawings.

2.02 FABRICATION

- A. Shop assembly:
 - 1. Cut and bend bars in accordance with provisions of ACI 315, ACI 318, and ACI 350.
 - 2. Bend bars cold.
 - 3. Provide bars free from defects and kinks and from bends not indicated on the Drawings.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verification of conditions:
 - 1. Reinforcing bars and welded wire fabric reinforcement: Verify that reinforcement is new stock free from rust scale, loose mill scale, excessive rust, dirt, oil, and other coatings which adversely affect bonding capacity when placed in the work.

3.02 PREPARATION

- A. Surface preparation:
 - 1. Reinforcing bars: Thin coating of red rust resulting from short exposure will not be considered objectionable. Thoroughly clean any bars having rust scale, loose mill scale, or thick rust coat.
 - 2. Cleaning of reinforcement materials: Remove concrete or other deleterious coatings from dowels and other projecting bars by wire brushing or sandblasting before bars are embedded in subsequent concrete placement.

3.03 INSTALLATION

- A. Reinforcing bars:
 - 1. No field bending of bars will be allowed.
 - 2. Welding:
 - a. Weld reinforcing bars where indicated on the Drawings or acceptable to the ENGINEER.
 - b. Perform welding in accordance with AWS D1.4 and welding procedures accepted by the ENGINEER.
 - 1) Conform to requirements for minimum preheat and interpass temperatures.
 - c. Do not tack weld reinforcing bars.
- B. Placing reinforcing bars:
 - 1. Accurately place bars to meet tolerances of ACI 318 and adequately secure them in position.
 - 2. Lap bars at splices as indicated on the Drawings or specified.
 - a. Unless specifically otherwise indicated on the Drawings, install bars at lap splices in contact with each other and fasten together with tie wire.
 - b. Where reinforcing bars are to be lap spliced at concrete joints, ensure that bars project from first concrete placement a length equal to or greater than the minimum lap splice length indicated on the Drawings.
 - c. Where lap splice lengths are not indicated on the Drawings, provide lap splice lengths in accordance with ACI 318 and ACI 350.
 - 3. Bar supports:
 - a. Provide a sufficient number to prevent sagging, to prevent shirting, and to support loads during construction; but in no case less than quantities and at locations as indicated in ACI 315.
 - b. Do not use brick, broken concrete masonry units, spalls, rocks, wood or similar materials for supporting reinforcing steel.
 - c. Do not use give away bars that have less cover than required by the Contract Documents. Do not adjust location of reinforcement required by the Contract Documents to provide cover to the giveaway bars.
 - 4. If not indicated on the Drawings, provide protective concrete cover in accordance with ACI 318 and ACI 350.
- C. Tying of bar reinforcement:
 - 1. Fasten bars securely in place with wire ties.
 - 2. Tie bars sufficiently often to prevent shifting.
 - 3. Provide at least three (3) ties in each bar length.
 - a. Do not apply to dowel lap splices or to bars shorter than 4-feet, unless necessary for rigidity.
 - 4. Tie slab bars at every intersection around periphery of slab.
 - 5. Tie wall bars and slab bar intersections other than around periphery at not less than every fourth intersection, but at not greater than following maximum spacings:

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

6. After tying wire ties, bend ends of wire ties in towards the center of the concrete section.
 - a. The cover for wire ties shall be the same as the cover requirements for reinforcing bars.
- D. Welded wire fabric reinforcement:
1. Install necessary wiring, spacing chairs, or supports to keep welded wire fabric in place while concrete is being placed.
 2. Bend fabric as indicated on the Drawings or required to fit work.
 3. Unroll or otherwise straighten fabric to make flat sheet before placing in the Work.
 4. Lap splice welded wire fabric as indicated on the Drawings.
 5. If lap splice length is not indicated on the Drawings, splice fabric in accordance with ACI 318 and ACI 350.

END OF SECTION

SECTION 03300

CAST-IN-PLACE CONCRETE

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Cast-in-place concrete.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the CONTRACTOR'S responsibility for scheduling and coordinating the work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR'S work.
 - 3. The following sections are related to the work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed work complies accurately with the Contract Documents.
 - a. Section 03071 - Epoxies.
 - b. Section 03150 - Concrete Accessories.
 - c. Section 03366 - Tooled Concrete Finishes.
 - d. Section 03931 - Epoxy Injection System.
 - e. Section 07900 - Joint Sealants.

1.02 REFERENCES

- A. American Concrete Institute (ACI):
 - 1. 318 - Building Code Requirements for Structural Concrete and Commentary.
 - 2. 350 - Code Requirements for Environmental Engineering Concrete Structures and Commentary.
 - 3. Manual of Concrete Practice.
- B. ASTM International (ASTM):
 - 1. C 31 - Standard Practice for Making and Curing Concrete Test Specimens in the Field.
 - 2. C 33 - Standard Specification for Concrete Aggregates.
 - 3. C 39 - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
 - 4. C 40 - Standard Test Method for Organic Impurities in Fine Aggregates for Concrete.
 - 5. C 42 - Standard Test Method of Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
 - 6. C 88 - Standard Test Method of Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.

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7. C 94 - Standard Specification for Ready-Mixed Concrete.
8. C 114 - Standard Test Methods for Chemical Analysis of Hydraulic Cement.
9. C 117 - Standard Test Method for Materials Finer than 75-m (No. 200) Sieve in Mineral Aggregates by Washing.
10. C 123 - Standard Test Method for Lightweight Particles in Aggregate.
11. C 131 - Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
12. C 136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
13. C 142 - Standard Test Method for Clay Lumps and Friable Particles in Aggregate.
14. C 143 - Standard Test Method for Slump of Hydraulic-Cement Concrete.
15. C 150 - Standard Specification for Portland Cement.
16. C 156 - Standard Test Method for Water Loss [from a Mortar Specimen] Through Liquid Membrane-Forming Curing Compounds for Concrete.
17. C 157 - Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete.
18. C 171 - Standard Specifications for Sheet Materials for Curing Concrete.
19. C 172 - Standard Practice for Sampling Freshly Mixed Concrete.
20. C 173 - Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method.
21. C 260 - Standard Specification for Air-Entraining Admixtures for Concrete.
22. C 289 - Standard Test Method for Potential Alkali-Silica Reactivity of Aggregates (Chemical Method).
23. C 295 - Standard Guide to Petrographic Examination of Aggregates for Concrete.
24. C 309 - Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
25. C 311 - Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland-Cement Concrete.
26. C 494 - Standard Specification for Chemical Admixtures for Concrete.
27. C 618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
28. D 75 - Standard Practice for Sampling Aggregates.
29. D 2103 - Standard Specification for Polyethylene Film and Sheeting.

1.03 DEFINITIONS

- A. Alkali: Is defined as the sum of sodium oxide and potassium oxide calculated as sodium oxide.
- B. Cementitious materials: Defined as portland cement and pozzolan admixture.
- C. Hairline crack: Crack with a crack width of less than 4 thousandths of an inch.

1.04 SYSTEM DESCRIPTION

- A. Performance requirements:
 1. General:
 - a. Except as otherwise specified, provide concrete composed of portland cement, fly ash, fine aggregate, coarse aggregate, and water so proportioned and

- mixed as to produce plastic, workable mixture in accordance with requirements as specified in this Section and suitable to specific conditions of placement.
- b. Proportion materials in a manner such that will secure lowest water-cement ratio which is consistent with good workability, plastic, cohesive mixture, and 1 which is within specified slump range.
 - c. Proportion fine and coarse aggregates in manner such as not to produce harshness in placing or honeycombing in structures.
2. It is the intent of this Section to secure for every part of the work concrete and grout of homogeneous structure, which when hardened will have required strength, watertightness, and durability:
- a. It is recognized that some surface hairline cracks and crazing will develop in the concrete surfaces.
 - b. Construction and expansion joints have been specified and positioned in structures as indicated on the Drawings, and curing methods specified, for purpose of reducing number and size of cracks, due to normal expansion and contraction expected from specified concrete mixes.
 - c. Class A, Class B, and Class D Concrete: Watertight: Repair cracks which develop in walls or slabs and repair cracks which show any signs of leakage until all leakage is stopped.
 - d. Pressure inject visible cracks, other than hairline cracks and crazing, in following areas with epoxy as specified in Section 03931 Epoxy Injection System:
 - 1) Floors and walls of water bearing structures.
 - 2) Walls and overhead slabs of passageways or occupied spaces, outsides of which are exposed to weather or may be washed down and are not specified to receive separate waterproof membrane.
 - 3) Other items not specified to receive separate waterproof membrane: Slabs over water channels, wet wells, reservoirs, and other similar surfaces.
 - e. Walls or slabs, as specified above, that leak or sweat because of porosity or cracks too small for successful pressure grouting: Seal on water or weather side by coatings of surface sealant system, as specified in this Section.
 - f. Grouting and sealing: Continue as specified above until structure is watertight and remains watertight for not less than 1 year after final acceptance or date of final repair, whichever occurs later in time.
3. Workmanship and methods: Provide concrete work, including detailing of reinforcing, conforming with best standard practices and as set forth in ACI 318, ACI 350, Manuals, and recommended practices.

1.05 SUBMITTALS

- A. Product data: Submit data completely describing products.
- B. Information on heating equipment to be used for cold weather concreting: Submit information on type of equipment to be used for heating materials and/or new concrete in process of curing during excessively cold weather.

- C. For conditions that promote rapid drying of freshly placed concrete such as low humidity, high temperature, and wind: Submit corrective measures proposed for use prior to placing concrete.
- D. Copies of tests of concrete aggregates: Submit certified copies in triplicate of commercial laboratory tests not more than 90 days old of all samples of concrete aggregates:
 - 1. Fine aggregate:
 - a. Clay lumps.
 - b. Reactivity.
 - c. Shale and chert.
 - d. Soundness.
 - e. Color.
 - f. Decantation.
 - 2. Coarse aggregate:
 - a. Clay lumps and friable particles.
 - b. Reactivity.
 - c. Shale and chert.
 - d. Soundness.
 - e. Abrasion loss.
 - f. Coal and lignite.
 - g. Materials finer than 200 sieve.
- E. Sieve analysis: Submit sieve analyses of fine and coarse aggregates being used in triplicate at least every 3 weeks and at any time there is significant change in grading of materials.
- F. Concrete mixes: Submit full details, including mix design calculations for concrete mixes proposed for use for each class of concrete:
 - 1. Include information on correction of batching for varying moisture contents of fine aggregate.
 - 2. Submit source quality test records with mix design submittal:
 - a. Include calculations for f'_{cr} based on source quality test records.
- G. Trial batch test data:
 - 1. Submit data for each test cylinder.
 - 2. Submit data that identifies mix and slump for each test cylinder.
- H. Sequence of concrete placing: Submit proposed sequence of placing concrete showing proposed beginning and ending of individual placements.
- I. Curing compound other than specified compound: Submit complete data on proposed compound.
- J. If either fine or coarse aggregate is batched from more than 1 bin: Submit analyses for each bin, and composite analysis made up from these, using proportions of materials to be used in mix.

- K. Cement mill tests: Include alkali content, representative of each shipment of cement for verification of compliance with specified requirements.
- L. Pozzolan Certificate of Compliance: Identify source of pozzolan and certify compliance in accordance with ASTM C 618.
- M. Information on mixing equipment.
- N. Drying shrinkage test data.

1.06 DELIVERY, STORAGE, AND HANDLING

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

1.07 PROJECT CONDITIONS

- A. Environmental requirements:
 - 1. Hot weather concreting:
 - a. When ambient air temperature is above 90 degrees Fahrenheit: Prior to placing concrete, cool forms and reinforcing steel to by water cooling to below 90 degrees Fahrenheit.
 - b. Temperature of concrete mix at time of placement: Keep temperature below 90 degrees Fahrenheit by methods which do not impair quality of concrete.
 - 2. Cold weather concreting:
 - a. Concrete placed below ambient air temperature of 45 degrees Fahrenheit and falling or below 40 degrees Fahrenheit: Make provision for heating water.
 - b. If materials have been exposed to freezing temperatures to degree that any material is below 35 degrees Fahrenheit: Heat such materials.
 - c. Heating water, cement, or aggregate materials:
 - 1) Do not heat in excess of 160 degrees Fahrenheit.
 - d. Protection of concrete in forms:
 - 1) Protect by means of covering with tarpaulins, or other acceptable covering acceptable to ENGINEER.
 - 2) Provide means for circulating warm moist air around forms in manner to maintain temperature of 50 degrees Fahrenheit for at least 5 days.
 - 3. For conditions that promote rapid drying of freshly placed concrete such as low humidity, high temperature, and wind: Take corrective measures to minimize rapid water loss from concrete:

- a. Furnish and use sufficient number of maximum and minimum self-recording thermometers to adequately measure temperature around concrete.

1.08 SEQUENCING AND SCHEDULING

- A. Schedule placing of concrete in such manner as to complete any single placing operation to construction or expansion joint.

PART 2 PRODUCTS

2.01 MATERIALS

A. Admixtures:

1. General:

- a. Do not use admixtures of any type, except as specified, unless written authorization has been obtained from the ENGINEER.
- b. Compatible with concrete and other admixtures.
- c. Do not use admixtures containing chlorides calculated as chloride ion in excess of 0.5 percent by weight.
- d. Use in accordance with manufacturer's recommendations and add each admixture to concrete mix separately.

2. Air entraining admixture:

- a. Provide all concrete with 5 percent, plus or minus 1 percent, entrained air of evenly dispersed air bubbles at time of placement.
- b. In accordance with ASTM C 260.

3. Pozzolan admixture:

- a. Fly ash in accordance with requirements of ASTM C 618, Class F, may be used as admixture in concrete made with Type II portland cement.
- b. Maximum of 15 percent by weight of pozzolan admixture to total weight of cementitious materials.
 - 1) The total weight of cementitious materials shall not be less than minimum cementitious materials listed in Table A.
- c. Do not use pozzolan admixture as an admixture in concrete made with portland-pozzolan cement.
- d. Loss on ignition for pozzolan admixture: Not exceed 4 percent.

4. Water reducing admixture:

- a. May be used at the CONTRACTOR'S option.
- b. In accordance with ASTM C 494, Type A or Type D.
- c. Not contain air-entraining agents.
- d. Liquid form before adding to the concrete mix.
- e. No decrease in cement is permitted as result of use of water reducing admixture.

5. Superplasticizers: Are not to be used without acceptance by ENGINEER.

B. Aggregate:

1. General:

- a. Provide concrete aggregates that are sound, uniformly graded, and free of deleterious material in excess of allowable amounts specified.
- b. Grade aggregate in accordance with ASTM C 136 and D 75.

- c. Provide unit weight of fine and coarse aggregate that produces in place concrete with weight of not less than 140 pounds per cubic foot.
 - d. Do not use aggregate made from recycled materials such as crushed and screened hydraulic-cement concrete, brick, and other construction materials.
2. Fine aggregate:
- a. Provide fine aggregate for concrete or mortar consisting of clean, natural sand or of sand prepared from crushed stone or crushed gravel.
 - b. Do not provide aggregate having deleterious substances in excess of following percentages by weight of contaminating substances.
 - 1) In no case shall total exceed percent listed.

Item	Test Method	Percent
Removed by decantation (dirt, silt, etc.)	ASTM C 117	3
Shale or Chert	ASTM C 123	1
	ASTM C 295*	1
Clay Lumps	ASTM C 142	1
* Test Method C 123 is used to identify particles in the sample lighter than 2.40 Specific Gravity. Test Method C 295 is used to identify which of the lightweight particles are shale or chert. If the results of Test Method C 123 are less than 1 percent, Test Method C 295 is not required.		

- c. Except as otherwise specified, grade fine aggregate from coarse to fine in accordance with requirements of ASTM C 33.
3. Coarse aggregate:
- a. General: Provide coarse aggregate consisting of gravel or crushed stone made up of clean, hard, durable particles free from calcareous coatings, organic matter, or other foreign substances.
 - b. Weight: Not exceeding 15 percent, for thin or elongated pieces having length greater than 5 times average thickness.
 - c. Deleterious substances: Not in excess of following percentages by weight, and in no case having total of all deleterious substances exceeding 2 percent.

Item	Test Method	Percent
Shale or chert	ASTM C 123	1.25
	ASTM C 295**	1
Coal and lignite	ASTM C 123	1/4
Clay lumps and friable particles	ASTM C 142	1/4
Materials finer than Number 200 sieve	ASTM C 117	1/2*

- * Except when material finer than Number 200 sieve consists of crusher dust, maximum amount shall be 1 percent.
- ** Test Method C 123 is used to identify particles in the sample lighter than 2.40 Specific Gravity. Test Method C 295 is used to identify which of the lightweight particles are shale, chert, coal, or lignite. If the results of Test Method C 123 are less than 1.25 percent (the minimum combined percentage of shale, chert, coal and lignite), Test Method C 295 is not required.

d. Grading:

- 1) Aggregate for Class A, B, C, and D concrete: In accordance with ASTM C 33, Size Number 57, except as otherwise specified or authorized in writing by the ENGINEER.
- 2) Aggregate for Class CE concrete for encasement of electrical conduits:
 - a) Graded in accordance with ASTM C 33, Size Number 8.

C. Concrete sealer:

- 1. Manufacturers: One of the following or equal:
 - a. ChemMasters, Madison, OH, Spray-Cure & Seal 25.
 - b. Tamms Industries, Luster Seal WB-300.

D. Conduit encasement coloring agent:

- 1. Color: Red color concrete used for encasement of electrical ducts, conduits, and similar type items.
- 2. Manufacturers: One of the following or equal:
 - a. Davis Company, #100 Utility Red.
 - b. I. Reiss Company, Inc., equivalent product.
- 3. Conduit encasement concrete: Mix into each cubic yard of concrete 10 pounds of coloring agent.

E. Evaporation retardant:

- 1. Manufacturers: One of the following or equal:
 - a. Master Builders Technologies, Cleveland, Ohio, Confilm.
 - b. Euclid Chemical Company, Cleveland, Ohio, Eucobar.

F. Keyway material: Steel, plastic, or lumber.

G. Nonslip abrasive:

- 1. Type: Aluminum oxide abrasive of size 8/16, having structure of hard aggregate, homogenous, nonglazing, rustproof, and unaffected by freezing, moisture, or cleaning compounds.
- 2. Manufacturers: One of the following or equal:
 - a. Exolon Company, Tonawanda, New York.
 - b. Abrasive Materials, Incorporated, Hillsdale, Michigan.

- H. Portland cement:
 - 1. General: Conform to specifications and tests in accordance with ASTM C 150, Types II or III, low alkali, except as specified otherwise.
 - 2. Low alkali portland: Have total alkali containing not more than 0.60 percent.
 - 3. Exposed concrete in any individual structure: Use only one brand of portland cement.
 - 4. Cement for finishes: Provide cement from same source and of same type as concrete to be finished.
- I. Plastic membrane curing: Use polyethylene film in accordance with ASTM C 171:
 - 1. Color: White.
 - 2. Thickness: Nominal thickness of polyethylene film shall not be less than 0.0040-inches when measured in accordance with ASTM D 2103. Thickness of polyethylene film at any point shall not be less than 0.0030 inches.
 - 3. Loss of moisture: Not exceed 0.055 grams per square centimeter of surface when tested in accordance with ASTM C 156.
- J. Sprayed membrane curing compound: Clear type with fugitive dye in accordance with ASTM C 309, Type 1D.
- K. Surface sealant system: Manufacturers: One of the following or equal:
 - 1. Radcon Laboratories, Inc., Las Vegas, Nevada, Formula Number 7.
 - 2. IPA Systems, Philadelphia, Pennsylvania, Duripal.
- L. Water:
 - 1. Water for concrete, Washing Aggregate, and Curing Concrete: Clean and free from oil and deleterious amounts of alkali, acid, organic matter, or other substances.
 - 2. Chlorides and sulfate ions:
 - a. Water for conventional reinforced concrete: Use water not containing more than 1,000 milligrams per liter of chlorides calculated as chloride ion, nor more than 1,000 milligrams per liter of sulfates calculated as sulfate ion.
 - b. Water for prestressed or post-tensioned concrete: Use water not containing more than 650 milligrams per liter of chlorides calculated as chloride ion, nor more than 800 milligrams per liter of sulfates calculated as sulfate ion.

2.02 EQUIPMENT

- A. Mixing concrete:
 - 1. Mixers may be of stationary plant, paver, or truck mixer type.
 - 2. Provide adequate equipment and facilities for accurate measurement and control of materials and for readily changing proportions of material.
 - 3. Mixing equipment:
 - a. Capable of combining aggregates, cementitious materials, and water within specified time into thoroughly mixed and uniform mass and discharging mixture without segregation.
 - b. Maintain concrete mixing plant and equipment in good working order and operated at loads, speeds, and timing recommended by manufacturer or as specified.
 - c. Proportion cementitious materials and aggregate by weight.

B. Machine mixing:

1. Batch plant shall be capable of controlling delivery of all material to mixer within 1 percent by weight of individual material.
2. If bulk cementitious materials are used, weigh them on separate visible scale which will accurately register scale load at any stage of weighing operation from zero to full capacity.
3. Prevent cementitious materials from coming into contact with aggregate or with water until materials are in mixer ready for complete mixing with all mixing water.
4. Procedure of mixing cementitious materials with sand or with sand and coarse aggregate for delivery to project site, for final mixing and addition of mixing water will not be permitted.
5. Retempering of concrete will not be permitted.
6. Discharge entire batch before recharging.
7. Volume of mixed material per batch: Not exceed manufacturer's rated capacity of mixer.
8. Mixers:
 - a. Perform mixing in batch mixers of acceptable type.
 - b. Equip each mixer with device for accurately measuring and indicating quantity of water entering concrete, and operating mechanism such that leakage will not occur when valves are closed.
 - c. Equip each mixer with device for automatically measuring, indicating, and controlling time required for mixing:
 - 1) Interlock device to prevent discharge of concrete from mixer before expiration of mixing period.

C. Transit-mixed concrete:

1. Mix and deliver in accordance with ASTM C 94.
2. Total elapsed time between addition of water at batch plant and discharging completed mix:
 - a. Not to exceed 90 minutes.
 - b. Elapsed time at project site shall not exceed 30 minutes.
3. Under conditions contributing to quick setting, total elapsed time permitted may be reduced by the ENGINEER.
4. Equip each truck mixer with device interlocked to prevent discharge of concrete from drum before required number of turns and furnish such device that is capable of counting number of revolutions of drum.
5. Continuously revolve drum after it is once started until it has completely discharged its batch:
 - a. Do not admit water until drum has started revolving.
 - b. Right is reserved to increase required minimum number of revolutions or to decrease designated maximum number of revolutions allowed, if necessary, to obtain satisfactory mixing. The CONTRACTOR will not be entitled to additional compensation because of such increase or decrease.

D. Other types of mixers: In case of other types of mixers, mixing shall be as follows:

1. Mix concrete until there is uniform distribution of materials, and discharge mixer completely before recharging.
2. Neither speed nor volume loading of mixer shall exceed manufacturer's recommendations.

3. Continue mixing for minimum of 1-1/2 minutes after all materials are in drum, and for batches larger than 1 cubic yard increase minimum mixing time 15 seconds for each additional cubic yard or fraction thereof.

2.03 MIXES

A. Measurements of materials:

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

B. Concrete proportions and consistency:

1. Concrete consistency and composition:
 - a. Provide concrete that can be worked readily into corners and angles of forms and around reinforcement without excessive vibration and without permitting materials to segregate or free water to collect on surface.
 - b. Prevent unnecessary or haphazard changes in consistency of concrete.
2. Ratio of coarse aggregate to fine aggregate: Not less than 1.0 or more than 2.0 for all concrete Classes, with exception of Class CE.
3. Aggregate:
 - a. Obtain aggregate from source that is capable of providing uniform quality, moisture content, and grading during any single day's operation.
4. Concrete mix water to cementitious materials ratio, minimum cementitious materials content, and slump range: Conform to values specified in Table A in this Section.
5. Concrete batch weights: Control and adjust to secure maximum yield. At all times, maintain proportions of concrete mix within specified limits.
6. Mix modification: If required, by the ENGINEER, modify mixture within limits set forth in this Section.

C. Concrete mixes:

1. Proportioning of concrete mix: Proportion mixes based on required average on compressive strength f'_{cr} .
2. Mixes:
 - a. Adjusting of water: After acceptance, do not change mixes without acceptance by ENGINEER, except that at all times adjust batching of water to compensate for free moisture content of fine aggregate.

- b. Total water content of each concrete class: Not exceed those specified in Table A in this Section.
 - c. Checking moisture content of fine aggregate: Furnish satisfactory means at batching plant for checking moisture content of fine aggregate.
 - 3. Change in mixes: Submit new mix design and undertake new trial batch and test program as specified in this Section.
- D. Hand mixed concrete:
- 1. Hand mix concrete only when acceptable to the ENGINEER.
 - 2. Prepare hand mixed concrete on watertight, level platform in batches not to exceed 1/3 cubic yard each.
 - 3. Aggregate:
 - a. First, spread required amount of coarse aggregate on platform in an even and uniform layer.
 - 1) Then over coarse aggregate, spread proper proportion of fine aggregate.
 - b. Depth of combined coarse and fine aggregate layers: Not be greater than 1 foot.
 - 4. Cementitious materials:
 - a. First, evenly spread required quantity of cementitious materials over fine aggregate.
 - b. Then turn entire batch with shovels at least 2 times before adding water.
 - 5. Water:
 - a. Then uniformly sprinkle or spray proper amount of water over batched materials.
 - b. Then turn with shovels not less than 3 times before concrete is removed from platform.
- E. Classes of concrete:
- 1. Provide concrete consisting of 5 classes: Classes A, B, C, D, and CE. Use where specified or indicated on the Drawings.
 - 2. Weight of concrete classes: Provide classes of concrete having minimum weight of 140 pounds per cubic foot.
 - 3. Class B concrete: Class B concrete may be substituted for Class A concrete, when high-early strength concrete is needed in areas specifically accepted by the ENGINEER and that do not require sulfate resistant concrete.
 - 4. Class C concrete: Class C concrete may be used for fill for unauthorized excavation, for thrust blocks and ground anchors for piping, for bedding of pipe, and where indicated on the Drawings.
 - 5. Class D concrete: Use Class D for precast concrete items.
 - 6. Class CE concrete: Use Class CE for electrical conduit encasements.
 - 7. All other concrete, unless specified or otherwise indicated on the Drawings: Use Class A concrete.

TABLE A CONCRETE WITH AIR ENTRAINMENT				
Class	Specified Compressive Strength f'c at 28 Days (Pounds per Square Inch)	Maximum Water-to- Cementitious Materials Ratio	Minimum Cementitious Materials per Cubic Yard of Concrete by Weight (Pounds)	Slump Range (Inches)
A	4,000	0.45	564	2 to 4
B (Type III cement)	4,000	0.45	564	2 to 4
C	2,500	0.62	423	3 to 6
D	4,500	0.45	658	2 to 4
CE	2,500	0.62	564	3 to 6

8. Pumped concrete: Provide pumped concrete that complies with all requirements of this Section.
9. Do not place concrete with slump outside limits indicated in Table A.
10. Classes:
 - a. Classes A, C, D, and CE concrete: Make with Type II low alkali portland cement.
 - b. Class B concrete: Make with Type III low alkali portland cement.
 - c. Admixtures: Provide admixtures as specified in this Section.

F. Air entraining admixture:

1. Add agent to batch in portion of mixing water.
2. Batch solution by means of mechanical batcher capable of accurate measurement.

2.04 SOURCE QUALITY CONTROL

A. Tests:

1. Trial batches:
 - a. After concrete mix designs have been accepted by ENGINEER, have trial batches of the accepted Class A, Class B, and Class D concrete mix designs prepared by testing laboratory acceptable to the ENGINEER.
 - b. Prepare trial batches using specified cementitious materials and aggregates proposed to be used for the work.
 - c. Prepare trial batches with sufficient quantity to determine slump, workability, consistency, and finishing characteristics, and to provide sufficient test cylinders.
 - d. Test cylinders: Provide cylinders having 6-inch diameter by 12-inch length and that are prepared in accordance with ASTM C 31 for tests specified in this Section.

- e. Determine slump in accordance with ASTM C 143.
- f. Test cylinders from trial batch:
 - 1) Test 8 cylinders for compressive strength in accordance with ASTM C 39:
 - a) Test 4 cylinders at 7 days and 4 at 28 days.
 - b) Establish ratio between 7 day and 28 day strength for mix. 7-day strength may be taken as satisfactory indication of 28-day strength provided effects on concrete of temperature and humidity between 7 day and 28 day are taken into account.
 - 2) Average compressive strength of 4 test cylinders tested at 28 days: Equal to or greater than required average compressive strength f'_{cr} on which concrete mix design is based.
- g. Drying shrinkage:
 - 1) Prepare 5 drying shrinkage specimens in accordance with ASTM C 157, except as modified in this Section.
 - 2) Remove drying shrinkage specimens from molds at age of 23 hours plus or minus 1 hour after trial batching, then immediately place them in water at 73 degrees Fahrenheit plus or minus 3 degrees for at least 30 minutes and then measure specimens within 30 minutes thereafter to determine original length.
 - a) Then submerge specimens in saturated limewater at 73 degrees Fahrenheit plus or minus 3 degrees for moist curing.
 - 3) Make measurement to determine expansion expressed as percentage of original length at age 7 days.
 - a) Use length at age 7 days as base length for drying shrinkage calculations.
 - 4) Immediately store specimens in humidity-controlled room maintained at 73 degrees Fahrenheit plus or minus 3 degrees and 50 percent plus or minus 4 relative humidity for remainder of test.
 - 5) Make and report measurements to determine shrinkage expressed as percentage of base length separately for 7, 14, 21, and 28 days of drying after 7 days of moist curing.
 - 6) Drying shrinkage deformation:
 - a) Measure drying shrinkage deformation of each specimen as difference between base length and length after drying at each test age.
 - b) Measure average drying shrinkage deformation of specimens to nearest 0.0001-inch at each test age.
 - c) If drying shrinkage of any specimen departs from average of test age by more than 0.0004-inch, disregard results obtained from that specimen and test another specimen.
 - d) Shrinkage of trial batch concrete at 28 days drying age shall not exceed 0.045 percent maximum.
- h. If trial batch tests do not meet specified requirements for slump, strength, workability, consistency, drying shrinkage, and finishing, change concrete mix design proportions and, if necessary, source of aggregate.
 - 1) Make additional trial batches and tests until an acceptable trial batch is produced that meets requirements of this Section.

- i. Perform test batches and tests required to establish trial batches and acceptability of materials without change in Contract Price.
 - j. Do not place concrete until the concrete mix design and trial batch have been accepted by ENGINEER.
2. Required average compressive strength:
- a. Determine required average compressive strength (f_{cr}) for selection of concrete proportions for mix design, for each class of concrete, using calculated standard deviation and its corresponding specified compressive strength f'_c , in accordance with ACI 318 and ACI 350.
 - b. When test records of at least 30 consecutive tests that span period of not less than 45 calendar days are available, establish standard deviation as in accordance with ACI 318 and ACI 350 and as modified in this Section.
 - c. Provide test records from which to calculate standard deviation that represent materials, quality control procedures, and conditions similar to materials, quality control procedures, and conditions expected to apply in preparation of concrete for the work.
 - d. Provide changes in materials and proportions within test records that are more restricted than those for the work.
 - e. Specified compressive strength (f'_c) of concrete used in test records: Within 1,000 pounds per square inch of that specified for the work.
 - f. When lacking adequate test records for calculation of standard deviation meeting requirements, determine required average compressive strength f_{cr} from following Table B.

TABLE B	
Specified Compressive Strength f'_c (pounds per square inch)	Required Average Compressive Strength f_{cr} (pounds per square inch)
Less than 3,000	$f'_c + 1,000$
3,000 to 5,000	$f'_c + 1,200$
Over 5,000	$1.10f'_c + 700$

3. Pozzolan admixture:
- a. Sampling and testing:
 - 1) Sample and test pozzolan admixture in accordance with ASTM C 311.
4. Aggregate:
- a. Testing of concrete aggregate is at CONTRACTOR'S expense.
 - b. If there is change in aggregate source or if there is a significant change in aggregate quality from same source, submit new set of design mixes covering each class of concrete and prepare new trial batches.
 - c. Sieves:
 - 1) Use sieves with square openings for testing grading of aggregates.
 - 2) Sieve analyses: If sieve analyses indicate significant change in materials, the ENGINEER may require that new mix design and trial batch be submitted and accepted before further placing of concrete.

- d. Sample aggregate in accordance with ASTM C 136 and D 75.
- e. Fine aggregate:
 - 1) Provide fine aggregate that does not contain strong alkali nor organic matter which gives color darker than standard color when tested in accordance with ASTM C 40.
 - 2) Provide aggregate having soundness in accordance with requirements of ASTM C 33 when tested in accordance with ASTM C 88.
 - 3) Provide aggregate complying with reactivity requirements of ASTM C 33 when tested in accordance with ASTM C 289.
- f. Coarse aggregate:
 - 1) Soundness when tested in accordance with ASTM C 88: Have loss not greater than 10 percent when tested with sodium sulfate.
 - 2) Abrasion Loss: Not exceed 45 percent after 500 revolutions when tested in accordance with ASTM C 131.
 - 3) Reactivity: Not exceed limits specified in Appendix of ASTM C 33 when tested in accordance with ASTM C 289.
- g. Portland cement:
 - 1) Determination alkali content: Determine by method set forth in ASTM C 114.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Liquid evaporation retardant:
 - 1. Under conditions which result in rapid evaporation of moisture from the surface of the concrete, immediately after the concrete has been screeded, coat the surface of the concrete with a liquid evaporation retardant.
 - 2. Apply the evaporation retardant again after each work operation as necessary to prevent drying shrinkage cracks.
 - 3. Conditions which result in rapid evaporation of moisture may include one or more of the following:
 - a. Low humidity.
 - b. Windy conditions.
 - c. High temperature.
- B. Surface sealant system:
 - 1. Apply as recommended by manufacturer published instructions.
 - 2. Where concrete continues to sweat or leak, apply additional coats of surface sealant until the sweating or leaks stop.
- C. Joints and bonding:
 - 1. As far as practicable construct concrete work as monolith.
 - 2. Locations of construction, expansion, and other joints are indicated on the Drawings or as specified in this Section.
 - 3. For the following structures, provide not less than 7 days between placements of concrete in adjacent concrete wall placements. Place concrete for slabs in

checkerboard pattern with not less than 7 days between placements of concrete in adjacent concrete slab placements.

4. Construction joints:
 - a. Where construction joints are not indicated on the Drawings, provide construction joints in slabs and walls at intervals not greater than 35-feet.
 - b. In order to preserve strength and watertightness of structures, make no other joints, except as authorized by the ENGINEER.
 - c. At construction joints, thoroughly clean concrete of laitance, grease, oil, mud, dirt, curing compounds, mortar droppings, or other objectionable matter by means of heavy sandblasting, and wash surfaces just prior to succeeding concrete placement.
 - d. At horizontal joints: Immediately prior to resuming concrete placing operations, thoroughly spread bed of grout not less than 1/2-inch in thickness nor more than 1-inch in thickness over horizontal joint surfaces.
 5. Keyways in joints:
 - a. Provide keyways in joints as indicated on the Drawings.
 - b. Treat lumber keyway material with form release coating, applied in accordance with manufacturer's instructions.
 6. Take special care to ensure that concrete is well consolidated around and against waterstops and waterstops are secured in proper position.
 7. Cleaning of construction joints:
 - a. Wash construction joints free of sawdust, chips, and other debris after forms are built and immediately before concrete or grout placement.
 - b. Should formwork confine sawdust, chips, or other loose matter in such manner that it is impossible to remove them by flushing with water, use vacuum cleaner for their removal, after which flush cleaned surfaces with water.
 - c. Provide cleanout hole at base of each wall and column for inspection and cleaning.
 8. Construction and expansion joints:
 - a. Constructed where and as indicated on the Drawings.
 - b. Waterstops, expansion joint material, synthetic rubber sealing compound, and other similar materials: As specified in Sections 03150 Concrete Accessories and 07900 Joint Sealants.
 9. Repair of concrete: Where it is necessary to repair concrete by bonding mortar or new concrete to concrete which has reached its initial set, first coat surface of set concrete with epoxy bonding agent as specified in Section 03071 Epoxies.
- D. Conveying and placing concrete:
1. Convey concrete from mixer to place of final deposit by methods that prevent separation or loss of materials.
 2. Use equipment for chuting, pumping, and conveying concrete of such size and design as to ensure practically continuous flow of concrete at delivery end without separation of materials.
 3. Design and use chutes and devices for conveying and depositing concrete that direct concrete vertically downward when discharged from chute or conveying device.
 4. Keep equipment for conveying concrete thoroughly clean by washing and scraping upon completion of any day's placement.

E. Placing concrete:

1. Place no concrete without prior authorization of the ENGINEER.
2. Do not place concrete until:
 - a. Reinforcement is secure and properly fastened in its correct position and loose form ties at construction joints have been retightened.
 - b. Dowels, bucks, sleeves, hangers, pipes, conduits, anchor bolts, and any other fixtures required to be embedded in concrete have been placed and adequately anchored.
 - c. Forms have been cleaned and oiled as specified.
3. Placement of concrete in which initial set has occurred, or of retempered concrete, will not be permitted.
4. Place no concrete during rainstorms or high velocity winds.
5. Protect concrete placed immediately before rain to prevent water from coming in contact with such concrete or winds causing excessive drying.
6. Keep sufficient protective covering on hand at all times for protection of concrete.
7. After acceptance, adhere to proposed sequence of placing concrete, except when specific changes are requested and accepted by the ENGINEER.
8. Notify the ENGINEER in writing of readiness, not just intention, to place concrete in any portion of the work:
 - a. Provide this notification in such time in advance of operations, as the ENGINEER deems necessary to make final inspection of preparations at location of proposed concrete placing.
 - b. Place forms, reinforcement, screeds, anchors, ties, and inserts in place before notification of readiness is given to the ENGINEER.
 - c. Depositing concrete:
 - 1) Deposit concrete at or near its final position to avoid segregation caused by rehandling or flowing.
 - 2) Do not deposit concrete in large quantities in one place and work along forms with vibrator or by other methods.
 - 3) Do not drop concrete freely into place from height greater than 5-feet.
 - 4) Use tremies for placing concrete where drop is over 5-feet.
 - 5) Commence placement of concrete on slopes, at bottom of slope.
9. Place concrete in approximately horizontal layers not to exceed 24-inches in depth and bring up evenly in all parts of forms.
10. Continue concrete placement without avoidable interruption, in continuous operation, until end of placement is reached.
11. After placement begins, it should continue without significant interruption. Precautions should be planned and implemented to prevent any delay, between layers being placed, from exceeding 20 minutes.
12. If concrete is to be placed over previously placed concrete and more than 20 minutes have elapsed, then spread layer of grout not less than 1/2-inch in thickness nor more than 1-inch in thickness over surface before placing additional concrete.
13. Placement of concrete for slabs, beams, or walkways:
 - a. If cast monolithically with walls or columns, do not commence until concrete in walls or columns has been allowed to set and shrink.
 - b. Allow set time of not less than one hour for shrinkage.

F. Consolidating concrete:

1. Place concrete with aid of acceptable mechanical vibrators.
2. Thoroughly consolidate concrete around reinforcement, pipes, or other shapes built into the work.
3. Provide sufficiently intense vibration to cause concrete to flow and settle readily into place and to visibly affect concrete over radius of at least 18-inches.
4. Vibrators:
 - a. Keep sufficient vibrators on hand at all times to vibrate concrete as placed.
 - b. In addition to vibrators in actual use while concrete is being placed, have on hand minimum 1 spare vibrator in serviceable condition.
 - c. Place no concrete until it has been ascertained that all vibrating equipment, including spares, are in serviceable condition.
5. Take special care to place concrete solidly against forms to leave no voids.
6. Take every precaution to make concrete solid, compact, and smooth, and if for any reason surfaces or interiors have voids or are in any way defective, repair such concrete in manner acceptable to the ENGINEER.

G. Footings and slabs on grade:

1. Do not place concrete on ground or compacted fill until subgrade is in moist condition acceptable to the ENGINEER.
2. If necessary, sprinkle subgrade with water not less than 6 or more than 20 hours in advance of placing concrete.
3. If it becomes dry prior to actual placing of concrete, sprinkle again, without forming pools of water.
4. Place no concrete if subgrade is muddy or soft.

H. Loading concrete:

1. Green concrete:
 - a. No heavy loading of green concrete will be permitted.
 - b. Green concrete is defined as concrete with less than 100 percent of the specified strength.
2. No backfill shall be placed against concrete walls, connecting slabs, or beams until the concrete has reached the specified strength.
3. Use construction methods, sequencing, and allow time for concrete to reach adequate strength to prevent overstress of the concrete structure during construction.

I. Curing concrete:

1. General:
 - a. Cure concrete by methods specified in this Section.
 - b. Cure concrete minimum of 7 days.
 - c. Cure concrete to be painted with water or plastic membrane.
 - d. Do not use curing compound on concrete surfaces that are to receive paint or upon which any material is to be bonded.
 - e. Water cure or plastic membrane cure concrete slabs that are specified to be sealed by concrete sealer.
 - f. Cure other concrete by water curing or sprayed curing membrane at the CONTRACTOR'S option.
 - g. Floor slabs may be cured using plastic membrane curing.

2. Water curing:
 - a. Keep surfaces of concrete being water cured constantly and visibly moist day and night for period of not less than 7 days.
 - b. Each day forms remain in place may count as 1 day of water curing.
 - c. No further curing credit will be allowed for forms in place after contact has once been broken between concrete surface and forms.
 - d. Do not loosen form ties during period when concrete is being cured by leaving forms in place.
 - e. Flood top of walls with water at least 3 times per day, and keep concrete surfaces moist at all times during 7 day curing period.
3. Sprayed membrane curing:
 - a. Apply curing compound to concrete surface after repairing and patching, and within 1 hour after forms are removed.
 - b. If more than 1 hour elapses after removal of forms, do not use membrane-curing compound, but use water curing for full curing period.
 - c. If surface requires repairing or painting, water cure such concrete surfaces.
 - d. Curing compound:
 - 1) Do not remove curing compound from concrete in less than 7 days.
 - 2) Curing compound may be removed only upon written request by the CONTRACTOR and acceptance by the ENGINEER, stating what measures are to be performed to adequately cure structures.
 - 3) Take care to apply curing compound in area of construction joints.
 - a) See that curing compound is placed within construction joint silhouette.
 - 4) After curing period is complete, remove curing compound placed within construction joint silhouette by heavy sandblasting prior to placing any new concrete.
 - 5) CONTRACTOR'S Option: Instead of using curing compound for curing of construction joints, such joints may be water cured.
 - 6) Apply curing compound by mechanical, power operated sprayer and mechanical agitator that will uniformly mix all pigment and compound.
 - 7) Apply compound in at least 2 coats.
 - 8) Apply each coat in direction 90 degrees to preceding coat.
 - 9) Apply curing compound in sufficient quantity so that concrete has uniform appearance and that natural color is effectively and completely concealed at time of spraying.
 - 10) Continue to coat and recoat surfaces until specified coverage is achieved and until coating film remains on concrete surfaces.
 - 11) Thickness and coverage of curing compound: Provide compound having film thickness that can be scraped from surfaces at any and all points after drying for at least 24 hours.
 - 12) The CONTRACTOR is cautioned that method of applying curing compound specified in this Section may require more compound than normally suggested by manufacturer of compound and also more than is customary in the trade.
 - 13) Apply amounts specified in this Section, regardless of manufacturer's recommendations or customary practice, if curing compound is used in place of water curing.

- 14) If the CONTRACTOR desires to use curing compound other than specified curing compound, coat sample areas of concrete wall with proposed curing compound and also similar adjacent area with specified compound in specified manner for comparison:
 - a) If proposed sample is not equal or better, in opinion of the ENGINEER, in all features, proposed substitution will not be allowed.
 - 15) Prior to final acceptance of the work, remove, by sandblasting or other acceptable method, any curing compound on surfaces exposed to view, so that only natural color of finished concrete is visible uniformly over entire surface.
4. Plastic membrane curing:
 - a. Polyethylene film may be used to cure slabs.
 - 1) Seal joints and edges with small sand berm.
 - b. Install plastic membrane as soon as concrete is finished and can be walked on without damage.
 - c. Keep concrete moist under plastic membrane.

3.02 CONCRETE FINISHING

- A. Provide concrete finishes as specified in Section 03366 Tooled Concrete Finishes.
- B. Edges of joints:
 1. Provide joints having edges as indicated on the Drawings.
 2. Protect wall and slab surfaces at edges against concrete spatter and thoroughly clean upon completion of each placement.
- C. Concrete sealer:
 1. Floors and slabs to receive concrete sealer: As specified in the Contract Documents on finish schedule.
 2. Seal floors and slabs at CONTRACTOR'S option:
 - a. All floor slabs except for the following:
 - 1) Those indicated on the Drawings to receive seamless Floor surfacing.
 - 2) Any slabs which receive concrete or grout surfacing, in lieu of water or curing compound.
 3. Apply concrete sealer:
 - a. Apply concrete sealer at coverage rate not to exceed 300 square feet per gallon.
 - b. Apply as soon as slab or floor will bear weight.
 - c. Sealer:
 - 1) Before applying concrete sealer, sweep entire surface clean with very soft bristled brush that will not mark finish and remove any standing water.
 - 2) Apply concrete sealer with sprayer.
 - 3) Use of paint rollers or mop is not acceptable.
 - 4) Workmen shall wear flat soled shoes which will not mark or scar surface.

- 5) Do not allow traffic on floors and slabs until concrete sealer has dried and hardened.

3.03 FIELD QUALITY CONTROL

A. Testing of concrete:

1. During progress of construction, the OWNER will have tests made to determine whether the concrete, as being produced, complies with requirements specified.
2. Tests will be performed in accordance with ASTM C 31, ASTM C 39, and ASTM C 172.
3. The OWNER will make and deliver test cylinders to the laboratory and testing expense will be borne by the OWNER.
4. Required number of cylinders:
 - a. Not less than 3 cylinder specimens, 6-inch diameter by 12-inch long, will be tested for each 150 cubic yards of each class of concrete with minimum of 3 specimens for each class of concrete placed and not less than 3 specimens for each half day's placement.
 - b. One cylinder will be broken at 7 days and 2 at 28 days.
5. The CONTRACTOR shall:
 - a. Remove concrete from the project site that does not meet specification requirements in regards to slump.
 - b. Make provisions for the OWNER to sample concrete for test specimens and provide manual assistance to the OWNER in preparing said specimens.

B. Air entraining admixture:

1. Test percent of entrained air in concrete at beginning of each placement, as often as necessary to keep entrained air within specified range, and when requested to do so by the ENGINEER.
2. Provide test equipment.
3. Do not use concrete that does not meet Specification requirements for air entrainment.
 - a. Remove such concrete from project site.
4. Test air entrainment in concrete in accordance with ASTM C 173.
5. The OWNER may at any time test percent of entrained air in concrete received on project site.

C. Enforcement of strength requirement:

1. Concrete is expected to reach higher compressive strength than that which is indicated in Table A as specified compressive strength f'_c .
2. Strength level of concrete: Will be considered acceptable if following conditions are satisfied:
 - a. Averages of all sets of 3 consecutive strength test results is greater or equal to specified compressive strength f'_c .
 - b. No individual strength test (average of 2 cylinders) falls below specified compressive strength f'_c by more than 500 pounds per square inch.
 - c. Whenever one, or both, of 2 conditions stated above is not satisfied, provide additional curing of affected portion followed by cores taken in accordance with ASTM C 42, ACI 318, and ACI 350 and comply with following requirements:

- 1) If additional curing does not bring average of 3 cores taken in affected area to at least specified compressive strength f'_c , designate such concrete in affected area as defective.
- 2) The ENGINEER may require the CONTRACTOR to strengthen defective concrete by means of additional concrete, additional reinforcement, or replacement of defective concrete, all of the CONTRACTOR'S expense.

3.04 ADJUSTING

A. Repair of defective concrete:

1. Remove and replace or repair defective work.
2. Correct defective work as specified.
3. Do not patch, repair, or cover defective work without inspection by the ENGINEER.
4. Provide repairs having strength equal to or greater than specified concrete for areas involved.
5. Preparation of concrete for repair:
 - a. Make no repair until ENGINEER has accepted method for preparing surface for repair.
 - b. Chip out and key imperfections in the work and make them ready for repair.
 - c. Surfaces of set concrete to be repaired: First coat with epoxy bonding agent as specified in Section 03071 Epoxies.
6. Methods of repair:
 - a. Dry pack method:
 - 1) Use for holes having depth nearly equal to or greater than least surface dimension of hole, for cone-bolt holes, and for narrow slots cut for repair.
 - 2) Smooth holes: Clean and roughen by heavy sandblasting before repair.
 - b. Mortar method of replacement:
 - 1) Use for holes too wide to dry pack and too shallow for concrete replacement.
 - 2) Comparatively shallow depressions, large or small, which extend no deeper than nearest surface reinforcement.
 - c. Concrete replacement:
 - 1) Use when holes extend entirely through concrete section or when holes are more than 1 square foot in area and extend halfway or more through the section.

END OF SECTION

SECTION 03301

CONCRETE WORK

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Concrete formwork, concrete accessories, concrete reinforcement, cast-in-place concrete mixing, placement and curing.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the CONTRACTOR'S responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR'S Work.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01330 - Submittal Procedures.
 - b. Section 03366 - Tooled Concrete Finishes.
 - c. Section 07900 - Joint Sealants.

1.02 REFERENCES

- A. American Concrete Institute (ACI):
 - 1. 117 - Standard Specifications for Tolerances for Concrete Construction and Materials.
 - 2. 305 - Hot Weather Concreting.
 - 3. 306 - Standard Specification for Cold Weather Concreting.
 - 4. 315 - Details and Detailing of Concrete Reinforcement.
 - 5. 318 - Building Code Requirements for Structural Concrete.
- B. ASTM International (ASTM)
 - 1. A 185 - Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete.
 - 2. A 615 - Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
 - 3. C 29 - Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate.
 - 4. C 31 - Standard Practice for Making and Curing Concrete Test Specimens in the Field.
 - 5. C 33 - Standard Specification for Concrete Aggregates.

6. C 40 - Standard Test Method for Organic Impurities in Fine Aggregates for Concrete.
7. C 88 - Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.
8. C 94 - Standard Specification for Ready-Mixed Concrete.
9. C 114 - Standard Test Methods for Chemical Analysis of Hydraulic Cement.
10. C 131 - Standard Test Method for Resistance to Degradation of Small-Size Course Aggregate by Abrasion and Impact in the Los Angeles Machine.
11. C 143 - Standard Test Method for Slump of Hydraulic-Cement Concrete.
12. C 150 - Standard Specification for Portland Cement.
13. C 156 - Standard Test Method for Water Loss [from a Mortar Specimen] Through Liquid Membrane-Forming Curing Compounds for Concrete.
14. C 171 - Standard Specification for Sheet Materials for Curing Concrete.
15. C 172 - Standard Practice for Sampling Freshly Mixed Concrete.
16. C 173 - Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method.
17. C 260 - Standard Specification for Air-Entraining Admixtures for Concrete.
18. C 289 - Standard Test Method for Potential Alkali-Silica Reactivity of Aggregates (Chemical Method).
19. C 309 - Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
20. C 311 - Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland-Cement Concrete.
21. C 494 - Standard Specification for Chemical Admixtures for Concrete.
22. C 618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
23. C 1017 - Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete.
24. D 1751 - Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).
25. D1752 - Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction.
26. D 2103 - Standard Specification for Polyethylene Film and Sheeting.

C. Concrete Reinforcing Steel Institute (CRSI).

1.03 DEFINITIONS

A. "Neat Cement Grout": Grout made from a mixture of portland cement and water.

1.04 SUBMITTALS

A. General:

1. Submittal in accordance with Section 01330 Submittal Procedures unless modified in this Section.

B. Product data:

1. Formwork:

- a. Formwork facing materials. Data on facing materials for concrete exposed to view in the finished work, if different from that specified in this Section.
- b. Form release agent. Manufacturer's name and catalog data, including materials safety data sheet and documentation of suitability for use in contact with potable water.
- c. Concrete bar supports:
- d. Precast concrete bar supports ("dobies"): manufacturer's product data indicating compression strength of concrete supports and material used for tie wires.
- e. Wire chairs and slab bolsters: manufacturer's product data.
- 2. Joint materials:
 - a. Preformed expansion joint material: manufacturer's name and catalog data with documentation of conformance to materials standards specified for each type and thickness of material.
 - b. Injected tube waterstops: manufacturer's name and catalog data for waterstop system including tubes and injection grout.
- 3. Reinforcement:
 - a. Mill certificates for each heat of steel provided.
- 4. Concrete materials:
 - a. Cement Mill Tests: Mill certificate in accordance with ASTM C 150 and including "Type" and results of testing for alkali content.
 - b. Concrete aggregates:
 - 1) Type, pit or quarry location, and producer's name.
 - 2) Commercial laboratory test reports, conducted within 90 days of the date of award of this Work, for samples of each aggregate proposed for use.
 - a) Fine aggregate: Gradation analysis, specific gravity, and reports of deleterious materials to document in accordance with ASTM C 33.
 - b) Coarse aggregate: Gradation analysis, specific gravity, and reports of deleterious materials to document in accordance with ASTM C 33 for each size used.
 - c. Admixtures: manufacturer's catalog cuts and product data indicating compliance with the standards specified.
- 5. Concrete mixes: Submit full details, including:
 - a. Mix proportions and concrete properties for each class of concrete proposed for use.
 - 1) Information on correction of batching for varying moisture contents of fine aggregate.
 - b. Data to establish the average compressive strength:
 - 1) If established by field test records, submit:
 - a) Product and test data for the materials actually used in the mix.
 - b) Actual mix proportions.
 - c) Field test data for slump, air content, and 28-day compressive strength.
 - 1. Include not less than 15 tests in accordance with ACI 318 Chapter 5.
 - 2) If established by testing of trial batches, submit:

- a) Confirmation that the materials and proportions used in the trial batches are those that will be provided for the mix.
 - b) Mix test data for slump, air content, and 28-day compressive strength.
 - 3) For either method, include calculations for:
 - a) Standard deviation calculated in accordance with ACI 318 Chapter 5 requirements.
 - b) Calculation of required average compression strength (f'_{cr}) using the calculated standard deviation.
 - c) Statement demonstrating that the average compression strength resulting from field-testing or trial batch testing for each mix ($f'_{c_{avg}}$) exceeds the minimum required average compressive strength (f'_{cr}) for that mix.
 - c. Submit source quality test reports with mix design submittal.
 - 1) Include calculations for required average compression strength of concrete (f'_{cr}) based on source quality test records.
 - 6. Concrete finishing and curing materials:
 - a. Manufacturer's name and product data sheets.
- C. Shop Drawings:
- 1. Reinforcement:
 - a. Submit drawings showing bending and placement of reinforcement.
 - 1) Drawings shall be in accordance with ACI 315.
 - 2) Clearly show placement, shapes, and dimensions of each bar listed in the bill of materials, including additional reinforcement at corners and openings required by details in the Contract Documents.
 - 3) Show splice locations and bar lengths reflecting CONTRACTOR'S intended placement sequence.
 - b. Drawings that, in the ENGINEER'S opinion, are not sufficiently clear or complete will be rejected and a re-submittal will be required.
 - 1) Such determination will be solely at the discretion of the ENGINEER, and rejection may occur with or without review comments.
- D. Samples:
- 1. Form ties: If requested by the ENGINEER.
 - 2. Concrete bar supports: If requested by the ENGINEER:
 - a. Precast reinforcement supports.
 - b. Wire reinforcement supports.
- E. Project record documents:
- 1. Concrete delivery tickets: Submit copies of concrete delivery tickets when requested by the ENGINEER.
 - 2. Field test reports:
 - a. Reports of field-testing for slump, temperature, unit weight, and air entrainment.
 - 1) Note location of the concrete in the structure, and include tag numbers of associated cylinders for compression strength tests with report.

- b. Testing laboratory reports of compression strength.

F. Notifications:

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

1.05 QUALITY ASSURANCE

- A. Tolerances on concrete construction: In accordance with ACI 117, unless more stringent requirements are specified in the Contract Documents.
- B. Concrete mixtures:
 1. Ensure that concrete produced has the specified characteristics in the freshly mixed state, and that those are maintained to during transport and delivery and to the point of final placement.

1.06 DELIVERY, STORAGE AND HANDLING

- A. Deliver, store, and handle concrete materials in manner as to prevent damage and inclusion of foreign substances.
- B. Deliver reinforcing steel bundled and tagged with identifying tags marked in a legible manner with waterproof markings showing the same designations as indicated on the submitted shop drawings.
 1. Store off the ground and protect from moisture, dirt, oil and other injurious contaminants.
- C. Protect concrete accessories for weather and direct exposure to sunlight before installation.

1.07 PROJECT CONDITIONS

A. Environmental requirements:

1. Hot weather concreting: Construct in accordance with ACI 305 during conditions when the ambient air temperature is above 90 degrees Fahrenheit.
2. Cold weather concreting: Construct in accordance with ACI 306 when ambient air temperature is below 40 degrees Fahrenheit, or is 45 degrees Fahrenheit and falling.
3. Conditions that promote rapid drying of freshly placed concrete, such as low humidity, high temperature, and wind: Take corrective action to minimize loss of water from the concrete.

1.08 SEQUENCING

- ### A. Schedule placing of concrete in such a manner as to complete any single placing operation to a construction, or expansion joint.

PART 2 PRODUCTS

2.01 FORMS

A. Forms:

1. Design and performance requirements:
 - a. Design and performance of formwork shall be the responsibility of the CONTRACTOR, subject to the requirements of the Contract Documents.
 - b. Design, construct, and brace formwork to:
 - 1) Carry all loads applied or transmitted, including the pressure resulting from placement and vibration of plastic concrete.
 - 2) Remain tight to prevent loss of mortar.
 - 3) Maintain specified tolerances and provide finished surfaces as specified in this Section.
 - c. Maximum deflection of facing materials and supporting members on surfaces exposed to view in the finished work: 0.0042 times the clear span (1/240).
 - d. Maximum deviation from alignment (horizontal or vertical): In accordance with ACI 117.
2. Form facing materials:
 - a. Surfaces exposed to view in the finished work:
 - 1) Facing materials shall produce a smooth, uniform texture on the concrete.
 - a) Do not use materials with raised grain, tears, worn edges, patches, dents, or other similar defects.
 - 2) Acceptable materials: Plywood with "C" or better face; plastic-faced plywood; tempered concrete form grade hardboard; or steel.
 - b. Surfaces not exposed to view in the finished work: No form facing material is specified.
3. Forms for chamfers and keyways:
 - a. Uniform steel, plastic, or lumber section of dimensions shown or specified.
 - b. Provide adequate stiffness and support to maintain a true line at the concrete surface.

- c. Treated if required to eliminate bond with the concrete.
- B. Form ties:
 - 1. General:
 - a. Provide form ties fabricated by recognized manufacturer of concrete forming equipment and suitable for use with the forming system selected.
 - b. Provide ties that accurately tie, lock, and spread forms.
 - 1) Do not use wire ties or wood spreaders.
 - c. Provide form ties of such design that, when forms are removed, the tie leaves no metal or other material within 1-1/2 inches of the surface of the concrete.
 - d. Do not allow tie holes through forms for ties to leak during concrete placement.
 - 2. Cone snap ties: Tie with removable plastic cone leaving a tapered depression having a minimum diameter of 1 inch at the surface of the concrete and a depth of 1-1/2 inches below the surface.
 - 3. Dry-pack mortar for filling cone snap tie holes: Proportioned mix of 1 part of portland cement to 1 part plaster sand with potable water added to provide a stiff consistency that can be driven into holes and properly compacted.
 - 4. Admixtures or additives are not permitted.
- C. Form release agent: Commercially manufactured, non-staining formwork release agent that will prevent absorption of water by the formwork and will prevent bond between the formwork and the concrete.
 - 1. Form release agent to comply with all local air quality management regulations.

2.02 JOINT MATERIALS

- A. Preformed synthetic sponge rubber expansion joint material:
 - 1. Elastic sponge rubber compound in accordance with ASTM D 1752, Type I.
 - 2. Concrete-gray color unless otherwise noted.
 - 3. Thickness: As indicated on the Drawings.
 - 4. Manufacturers: The following or equal:
 - a. Right Pointe: Sponge Rubber Expansion Joint.
- B. Preformed bituminous fiber expansion joint material:
 - 1. Asphalt-impregnated fiberboard in accordance with ASTM D 1751.
- C. Sealants and caulking: As specified in Section 07900 Joint Sealants.
- D. Injected tube waterstops:
 - 1. System composed of permeable injection tubes consisting of a reinforcing spiral covered with inner and outer protective membranes, injected polyurethane grout, and accessories required for installation.
 - a. Grout shall cure to a flexible, closed-cell, polyurethane foam resistant to degradation under cycles of wetting and drying, and to chemicals found in concrete water treatment structures.
 - b. System and grout shall be certified in accordance with NSF 61 for use in contact with potable water.
 - 2. Manufacturers: The following, or equal:

- a. DeNeef Construction Chemicals, Inc. Injecto Tube with Hydro Active Flex LV polyurethane grout.

2.03 REINFORCEMENT

A. Materials:

1. Deformed bars: In accordance with ASTM A 615 Grade 60.
2. Welded wire fabric: Sheets of plain wire in accordance with ASTM A 185.
3. Bar supports:
 - a. Over ground or "mud mat":
 - 1) Precast concrete blocks with cast-in annealed steel tie wires, 16 gauge or heavier.
 - a) Compressive strength of blocks equal to or exceeding the compressive strength of the surrounding concrete.
 - 2) Height as required for minimum 3 inches of clear concrete cover below reinforcement.
 - 3) Minimum block "footprint" of 4 square inches, or as required to supporting load from reinforcement while maintaining the required concrete cover.
 - b. Wire supports: Stainless steel in accordance with CRSI Class 2, Type B.
4. Tie wire: Annealed steel.

B. Fabrication:

1. Cut and cold-bend bars in accordance with provisions of ACI 315 and ACI 318.
2. Fabricate reinforcement to the tolerances in accordance with ACI 117.
3. Provide bars free from defects and kinks and from bends not indicated on the Drawings.

2.04 CONCRETE MIXES

A. General:

1. Pre-construction testing of materials and mixes to demonstrate that they comply with the requirements of this Section shall be at the CONTRACTOR'S expense.
2. Mixes shall be ready-mix or transit-mixed concrete in accordance with ASTM C 94.
 - a. Hand-mixed batches shall not be used.
3. Submit documentation that the proposed concrete mixes will conform to the requirements of this Section and will produce concrete having the required proportions and properties specified in this Section.
4. Proportion mixes to conform to requirements for workability and durability specified in this Section.
 - a. Provide concrete with workability and consistency that can be readily worked into corners and angles of forms and around reinforcement without excessive vibration and without permitting materials to segregate or free water to collect on the surface.
 - b. Control and adjust batch weights to secure maximum yield.
 - 1) At all times, maintain proportions of concrete mix within specified limits.
5. Cement content:

- a. Use only 1 brand of portland cement for all exposed concrete surfaces in any single structure.
- b. Minimum cementitious materials content: Conform to values specified in Table A.
- c. Ratio of water to cementitious materials: Conform to values specified in Table A.

TABLE A CONCRETE REQUIREMENTS BY CLASS				
Class	Specified Compressive Strength f'c at 28 Days (Pounds per Square Inch)	Maximum Water-to- Cementitious Materials Ratio	Minimum Cementitious Materials per Cubic Yard of Concrete by Weight (Pounds)	Slump Range (Inches)
A	4,000	0.45	564	2 to 4
B (Type III cement)	4,000	0.45	564	2 to 4
C	2,500	0.62	423	3 to 6
CE	2,500	0.62	564	3 to 6

6. Ratio of coarse aggregate to fine aggregate: Not less than 1.0 or more than 2.0 for all concrete classes, with exception of Class CE.
7. Admixtures: Use in accordance with manufacturer's instructions.
 - a. Air entraining admixture: Provide all concrete with entrained air content of 6 percent within 1 percent consisting of evenly dispersed air bubbles.
 - b. Water reducing admixture:
 - 1) Required in all concrete mixes.
 - 2) No decrease in cementitious materials content is permitted as a result of use of water reducing admixture.
 - c. High range water reducing admixtures/plasticizing admixtures:
 - 1) Proportion concrete for a slump of 2 to 4 inches before the admixture is added, and a maximum slump of 8 inches after the admixture is added.
8. Pozzolans:
 - a. Fly ash: Maximum of 15 percent by weight of total weight of cementitious materials (cement plus fly ash).
 - b. Other pozzolans shall not be used without prior acceptance by the ENGINEER.
9. Average compression strength (f'c):
 - a. Proportion each concrete mix to provide the required average compressive strength (f'cr) determined in accordance with the provisions of ACI 318 Chapter 5.
 - b. Determine required average compressive strength (f'cr) for each class of concrete using the specified compressive strength of the mix, f'c, and the standard deviation in accordance with ACI 318.

- 1) Establish the standard deviation in accordance with ACI 318.
- 2) Documentation of standard deviation based on field test records.
 - a) Calculate standard deviation in accordance with ACI 318 procedures using test records that:
 1. Represent materials, quality control procedures, and conditions similar to materials, quality control procedures, and conditions expected for this Work.
 2. Do not include provisions on materials that are more restrictive than the materials proposed for use.
 3. Represent a mix design proportioned to provide a specified compressive strength (f'_c) within 1,000 pounds per square inch of that specified in this Section.
- 3) Documentation of standard deviation based on trial batches plus empirical code requirements:
 - a) When records of at least 15 consecutive tests spanning a period of not less than 45 calendar days are unavailable, determine required average compressive strength (f'_{cr}) from Table B:

TABLE B	
Specified Compressive Strength f'_c (pounds per square inch)	Required Average Compressive Strength f'_{cr} (pounds per square inch)
Less than 3,000	$f'_c + 1,000$
3,000 to 5,000	$f'_c + 1,200$

B. Constituent materials:

1. Portland cement: Conform to specifications and tests in accordance with ASTM C 150, Type II or Type I/II, Low Alkali; or ASTM C 150, Type III, Low Alkali.
 - a. Low Alkali materials shall be those having total alkali content of not more than 0.60 percent when determined by method in accordance with ASTM C 114.
 - b. Cement for finishes: Provide cement from same source and of same type as concrete to be finished.
2. Aggregates:
 - a. General:
 - 1) Provide concrete aggregates that are sound, uniformly graded, and free of deleterious material in excess of the amounts specified.
 - 2) Do not use aggregate made from recycled materials such as crushed and screened hydraulic-cement concrete, brick, or other construction waste.
 - 3) Obtain aggregate from source that is capable of providing uniform quality, moisture content, and grading during any single day's operation.
 - b. Fine aggregate:
 - 1) Provide fine aggregate consisting of clean, natural sand or of sand prepared from crushed stone or crushed gravel and in accordance with ASTM C 33 and the following:

- a) Alkali and organics: Not containing strong alkali nor organic matter yielding a color darker than “standard color” when tested in accordance with ASTM C 40.
 - b) Reactivity: Complying with reactivity requirements in accordance with ASTM C 33 when tested in accordance with ASTM C 289.
 - c. Coarse aggregate:
 - 1) Provide coarse aggregate consisting of gravel or crushed stone made up of clean, hard, durable particles free from calcareous coatings, organic matter, or other foreign substances and in accordance with ASTM C 33, Class 4S and the following:
 - a) Soundness when tested in accordance with ASTM C 88:
 - 1. Have loss not greater than 10 percent when tested with sodium sulfate.
 - b) Abrasion loss: Not exceed 45 percent after 500 revolutions when tested in accordance with ASTM C 131.
 - c) Reactivity: Not exceeding limits specified in Appendix of ASTM C 33 when tested in accordance with ASTM C 289.
 - 2) Grading:
 - a) Aggregate for Class A, B, C, and D Concrete: In accordance with ASTM C 33 Size Number 57.
 - b) Aggregate for Class CE Concrete: In accordance with ASTM C 33 for Size Number 8.
 - c) Where a combination of 2 or more sizes of coarse aggregate are used, the gradation of the blend shall conform to the grading requirements in accordance with ASTM C 33 for the size number specified.
- 3. Water:
 - a. Water for concrete mixes, for washing aggregate, and for curing concrete: Potable water, clean and free from oil and deleterious amounts of alkali, acid, organic matter, or other substances.
- 4. Admixtures:
 - a. General:
 - 1) Do not use admixtures, except those specified, unless written authorization has been obtained from the ENGINEER.
 - 2) Admixtures shall be compatible with concrete constituents and shall be from the same manufacturer to provide compatibility with other admixtures.
 - 3) Do not use admixtures containing chlorides in excess of 0.5 percent by weight when calculated as chloride ion.
 - b. Air entraining admixture: In accordance with ASTM C 260.
 - c. Fly ash: In accordance with ASTM C 618, Class C.
 - 1) Sampling and testing: In accordance with ASTM C 311.
 - 2) Loss on ignition: Not to exceed 4 percent.
 - d. Water reducing admixture: In accordance with ASTM C 494, Type A or Type D, not containing air-entraining agents.
 - e. High range water reducing admixtures/plasticizing admixtures: Use shall produce non-segregating concrete mixture with little bleeding that remains in a plastic state for not less than 2 hours.

- 1) High range water reducing admixtures: In accordance with ASTM C 494, Type F.
 - 2) Plasticizing admixtures: In accordance with ASTM C 1017, Type I.
 - f. Electrical conduit encasement coloring admixture: To produce red-colored concrete used for encasement of electrical ducts, conduits, and similar items.
 - 1) Conduit encasement concrete: Mix into each cubic yard of concrete 10 pounds of coloring agent.
 - 2) Manufacturers: One of the following or equal:
 - a) Davis Colors, #100 Utility Red.
 - b) I. Reiss Company, Inc., equivalent product.
- C. Concrete mix design requirements by class:
1. Provide concrete mixes by classes as specified in this Section.
 2. Use each class at the locations specified or indicated on the Drawings.
 - a. Class A Concrete: General use. Use at all locations unless otherwise indicated on the Drawings or listed in the following paragraphs.
 - b. Class B Concrete:
 - 1) May be substituted for Class A concrete for elements where high-early strength concrete is needed and that do not require sulfate resistant concrete.
 - 2) Use only after prior acceptance by the ENGINEER.
 - c. Class C Concrete: May be used as fill for unauthorized excavation, for thrust blocks and ground anchors for piping, for bedding of pipe, and elsewhere as indicated on the Drawings.
 - d. Class CE Concrete: Use for electrical conduit encasements.
- D. Concrete mixes: Source quality control:
1. Mix submittal and acceptance:
 - a. Do not place concrete until the concrete mix design and the results of any trial batch testing have been accepted by the ENGINEER.
 - b. If the ENGINEER requires changes to the mix design, modify mixes within limits set forth in this Section and submit new mix design for ENGINEER'S review.
 - c. After acceptance, do not change mixes or mix proportions without prior acceptance by the ENGINEER.
 - 1) Exception:
 - a) At all times, adjust batching of water to compensate for free moisture content of aggregates.
 - b) Total water content in the mix shall not exceed that specified.
 - d. If there is change in source of cement or aggregate, or if there is a significant change in the characteristics or quality of any constituent material received a source already approved to supply materials, submit new design mixes for each class of concrete affected.

2.05 CONCRETE FINISHING AND CURING MATERIALS

- A. Evaporation retardant:
1. Manufacturers: One of the following or equal:
 - a. Master Builders Technologies, Cleveland, Ohio, Confilm.

- b. Euclid Chemical Company, Cleveland, Ohio, Eucobar.
- B. Plastic membrane:
 - 1. White polyethylene film in accordance with ASTM C 171:
 - a. Nominal thickness not less than 0.0040 inches when measured in accordance with ASTM D 2103.
 - 1) Thickness at any point not less than 0.0030 inches.
 - b. Loss of moisture: Not to exceed 0.055 grams per square centimeter of surface when tested in accordance with ASTM C 156.
- C. Sprayed-on membrane curing compound:
 - 1. In accordance with ASTM C 309, Type 1D.
 - 2. Clear with fugitive dye.

PART 3 EXECUTION

3.01 GENERAL

- A. Preparation:
 - 1. Use construction methods and sequences that allow time for concrete to reach adequate strength to prevent damage to or overstress of the concrete structure or its elements during construction.
 - 2. Schedule placing of concrete in such a manner as to complete any single placing operation between designated construction, contraction, or expansion joints.
 - a. Place concrete for beams, girders, brackets, column capitals, haunches, and drop panels at the same time as the concrete for the adjacent slabs.
- B. Verification of conditions:
 - 1. Do not place concrete until:
 - a. Forms have been cleaned and oiled as specified.
 - b. All forms have been thoroughly checked for alignment, level, strength, and accurate location of reinforcement, joint accessories, and all mechanical and electrical inserts or other embedded items.
 - c. Reinforcement is secure and properly fastened in its correct position.
 - d. Dowels, bucks, sleeves, hangers, pipes, conduits, anchor bolts, and any other fixtures required to be embedded in concrete have been placed and adequately anchored.
 - e. Forms are aligned and secured, and loose form ties at construction joints have been retightened.
 - 2. Notify the ENGINEER in writing of readiness, not just intention, to place concrete in any portion of the work:
 - a. Provide this notification in such time in advance of operations, as the ENGINEER deems necessary to make final observation of preparations at location of the concrete placement.
 - b. Have forms, reinforcement, screeds, anchors, ties, embeds and inserts in place before notifying ENGINEER of readiness for final observations.
 - 3. Do not place concrete until ENGINEER has completed final observations of conditions at the placement, and has given acceptance to proceed.

3.02 FORMING

A. General

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

B. Constructing and erecting formwork:

1. Brace and anchor formwork to ensure vertical and lateral stability and to maintain finish tolerances when subjected to uplift pressures and lateral pressures from plastic concrete.
 - a. Ensure that formwork is positioned, braced, and firmly held against previously placed concrete to maintain true surfaces and to prevent loss or leaking of mortar at construction joints.
 - 1) At joints with flush surfaces exposed to view, lap contact surface of form a maximum of 1 inch over the previously placed concrete.
 - b. Design and construct forms with sufficient strength and stiffness that deflections resulting from loading by plastic concrete will not exceed the surface tolerance limits specified.
 - c. Set facing materials in an orderly and symmetrical arrangement, keeping the number of seams to a practical minimum.
 - d. Form ties: Tie forms together using cone snap ties placed at not more than 2 foot centers vertically and horizontally.
 - e. Construct formwork to permit easy removal without damage to formed surfaces.
 - f. Provide temporary openings at the base of column and wall formwork to allow cleaning and inspection immediately before concrete placement.
 - g. Cracks, openings, or offsets at joints in formwork: Close those that are 1/16 inch or larger by tightening forms or by filling with acceptable crack filler.
2. Where forms are re-used, clean surfaces of mortar, grout, and foreign materials before coating with form release agent and setting.
3. Cover formwork surfaces with form release agent to prevent bond with the concrete.
 - a. Do not allow form release agent to puddle in the forms.
 - b. Do not allow form release agent to contact reinforcement, embeds, or previously placed concrete.
4. Provide runways supported directly on the formwork for moving equipment and supplies during preparations for concreting.

- a. Do not rest such runways on reinforcement.
- C. Embeds, joints, and accessories:
 - 1. Position pipes, sleeves, conduits, inserts, anchors, castings, and other embedded items in the forms, and anchor to formwork to prevent displacement.
 - 2. Fill voids in sleeves, pipes, inserts and anchor slots with readily removable material, and seal if required to prevent entry of mortar.
 - 3. For pipe or conduit runs, position embeds to allow at least 3 inches of clear concrete separation between parallel runs of pipes, conduits or any combination of these items with each other or with reinforcement.
- D. Removing formwork:
 - 1. Remove forms after the specified time for curing and protection has been provided and when operations will not damage concrete.
 - 2. Immediately after forms are removed, carefully examine concrete surfaces.
 - a. Report any irregularities in surfaces and finishes to the ENGINEER.
 - b. Where surface repairs are needed, contact ENGINEER with description of conditions and description of repair procedures before proceeding with work.
 - 3. Immediately follow form removal with installation of specified curing materials and procedures.
 - 4. After forms are removed from wall and curing is complete, fill tie holes as follows:
 - a. Remove form ties and cones from surfaces.
 - b. Roughen cone-shaped tie holes by heavy sandblasting before repair.
 - c. Clean and dampen tie holes, maintaining a saturated surface for at least 2 hours before applying dry-pack mortar.
 - d. Dry pack cone-shaped tie holes with dry-pack mortar as specified in this Section.

3.03 PLACING CONCRETE REINFORCEMENT, EMBEDS, AND ACCESSORIES

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

- a. Support wire fabric from reinforcing supports.
 - 1) Do not place fabric on grade or forms and lift into subsequently placed concrete.
 - 2) Take care to maintain specified position of wire fabric in the concrete section and to prevent bending, draping, or kinking of the wires.
 2. Use number of supports required to prevent reinforcement from sagging and to support loads during construction, but in no fewer quantities and locations than required in accordance with ACI 315.
 3. Do not:
 - a. Use brick, broken concrete masonry units, concrete spalls, rocks, or other such material for supporting reinforcement.
 - b. Support reinforcement on additional reinforcing bars installed with less cover than that required by the Contract Documents ("give away bars").
 - c. Adjust location of reinforcement indicated on the Drawings to increase cover over support bars.
 4. Furnish and use templates for placing column dowels.
- C. Placing reinforcement:
 1. Locate reinforcement to provide minimum clear concrete cover specified.
 - a. Where cover is not specified, in accordance with ACI 318.
 2. Accurately place reinforcement in accordance with the tolerances of ACI 117.
 - a. Where reinforcement must be moved beyond the specified placing tolerances to avoid interference with other reinforcement, conduits, or embeds, submit the proposed arrangement for ENGINEER'S review.
 3. Fasten reinforcement securely in place with wire ties.
 - a. After tying, bend ends of wire ties inward towards the center of the concrete to match clear concrete cover provided for reinforcement.
 4. Do not weld reinforcing bars or wires.
 5. Deformed reinforcing bars:
 - a. Tie slab bars at every intersection around the perimeter of slabs.
 - b. Tie wall bar and slab bar intersections, other than those around the perimeter, at every fourth intersection, but not more than 48 inches on center each way.
 - c. Lap splices:
 - 1) Lap reinforcement at splices as indicated on the Drawings or specified.
 - 2) Unless indicated on the Drawings, install lap splices with bars in contact and fastened together with tie wire.
 - 3) If lap splice length is not indicated on the Drawings, install in accordance with ACI 318.
 6. Welded wire fabric reinforcement:
 - a. Bend fabric as indicated on the Drawings or required to fit work.
 - b. Unroll or otherwise straighten fabric to make perfectly flat sheet before placing in the Work.
 - c. Extend welded wire fabric across concrete section to provide fabric to within 2 inches of vertical concrete edges.
 - d. Lap splice welded wire fabric as indicated on the Drawings.

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

3.04 BATCHING, MIXING, TRANSPORTING AND DELIVERING CONCRETE

A. General:

1. Measure, batch, mix, transport, and deliver concrete in accordance with ASTM C 94.

B. Measuring and batching:

1. Measure materials by weighing, except as otherwise specified or where other methods are specifically authorized in writing by the ENGINEER.
2. On-site volumetric batching using pre-packaged dry materials is not permitted.
3. Measuring or weighing devices:
 - a. Furnish apparatus for weighing aggregates and cementitious materials that is suitably designed and constructed for this purpose.
 - b. Furnish devices that have capability of providing successive quantities of individual material that can be measured to within 1 percent of desired amount of that material.
 - c. Shall bear valid seal of the verification by the authority having jurisdiction.
 - d. Subject to review by the ENGINEER.
4. Weighing cementitious materials: Weigh cementitious materials separately.
5. Furnish satisfactory means for checking moisture content of aggregates before batching.
 - a. Adjust mix water to compensate for free moisture content of aggregate.
6. Mixing water:
 - a. Measure by volume or by weight.
 - b. Maximum water-to-cementitious materials ratio for each concrete class shall not exceed that specified in Table A of this Specification.
7. Admixtures:
 - a. Provide admixtures as specified.
 - b. Batch solutions by means of mechanical batcher capable of accurate measurement.

C. Mixing and transporting:

1. Mixing:
 - a. Equip each truck mixer with device capable of counting number of drum revolutions and interlocked to prevent discharge of concrete from drum before required number of turns is complete.
 - b. Once drum revolutions commence, continuously revolve drum until it has completely discharged its batch.
 - c. Do not add water until drum commences revolutions.
 - d. The ENGINEER may require an increase required minimum number of revolutions or a decrease in the designated maximum number of revolutions if necessary to obtain satisfactory mixing.
 - 1) Incorporate such changes without additional costs to the OWNER.
2. Do not exceed the following time period for mixing and delivery:

- a. Total elapsed time from addition of water at batch plant through discharging of completed mix: Not to exceed 90 minutes, nor 300 revolutions of the mixer drum.
 - b. Total elapsed time at project site: Not to exceed 30 minutes.
 - c. Under conditions contributing to quick setting, the ENGINEER may reduce total elapsed time permitted.
- D. On-site acceptance of concrete mixes:
- 1. Concrete shall possess the properties specified in this Section at the point of placement.
 - 2. Do not place concrete:
 - a. Having slump outside the limits indicated in Table A.
 - b. That does not conform to specifications for entrained air content.
 - c. For which the total elapsed time of mixing or elapsed time at the site exceeds the specified maximums.

3.05 CONVEYING, DEPOSITING, CONSOLIDATING AND FINISHING CONCRETE

- A. Preparation:
- 1. General:
 - a. Clean construction joints and formed surfaces of dirt, sawdust, chips, and other debris after forms are built and immediately before concrete or grout placement.
 - 1) Use vacuum cleaner if required to provide clean surfaces.
 - b. Remove snow, ice, frost, and standing water from surfaces of formwork, reinforcement, and embeds in contact with concrete.
 - c. Secure reinforcement, joint materials, anchors, embeds and other items in place.
 - d. Obtain ENGINEER'S observation and acceptance of preparations.
 - e. During conveying, placement, consolidation, and finishing of concrete, protect surrounding construction, including concrete walls and slab surfaces, from concrete splatter.
 - 1) Thoroughly clean surrounding construction at the completion of each placement.
 - 2. Slabs or concrete construction on grade:
 - a. Provide subgrade preparation, base materials, and compaction as required by the Contract Documents.
 - b. Remove loose soils, debris, standing water, snow, or ice from subgrade.
 - c. Provide moist subgrade with no standing or free water and no muddy or soft spots.
 - 1) When subgrade is not moist, sprinkle with water not less than 2 nor more than 6 hours in advance of placing concrete.
 - 2) If subgrade becomes dry prior to actual placing of concrete, sprinkle again, without forming pools of water.
 - 3. Weather conditions:
 - a. Hot weather: In hot weather conditions, make provisions in advance of placement for windbreaks, shading, fogging, sprinkling, ponding, or wet covering.

- b. Cold weather: In cold weather conditions, make provisions to maintain the required concrete temperatures without overheating or drying, and without exposing concrete to carbon dioxide from heater exhaust.
 - c. Precipitation:
 - 1) Do not begin placements while rain, sleet, or snow is falling or anticipated, or unless adequate protection is provided.
 - 2) Do not allow precipitation to increase concrete water content or to damage the surface of the concrete.
 - d. Wind:
 - 1) Do not begin placements during wind events that will blow dust or debris into the plastic concrete.
 - 2) Do not allow wind-blown debris to become embedded in or to damage the surface of the concrete.
 - 3) At all times, have sufficient coverings on hand to protect new concrete from excessive drying or blowing debris.
- B. Conveying concrete:
 - 1. Convey concrete from mixer to place of final deposit by methods that prevent segregation or loss of materials.
 - 2. Use chutes, pumps, and conveyors of size and design that will ensure continuous flow of concrete at delivery end to prevent the formation of cold joints.
 - 3. Design and use chutes and devices for conveying and depositing concrete that direct concrete vertically downward when discharged from the chute or conveying device.
 - 4. Keep conveying equipment clean by thoroughly washing and scraping upon completion of any placement.
- C. Depositing concrete:
 - 1. Do not place concrete under the following conditions:
 - a. After initial set has occurred.
 - b. When re-tempering has occurred.
 - 2. Deposit concrete at or near its final position to avoid segregation caused by rehandling or flowing.
 - a. Do not use vibrators to move concrete from its point of deposit.
 - b. Use tremies for placing concrete where drop is over 5 feet.
 - 3. Place concrete continuously in approximately horizontal layers not exceeding 24 inches in depth. Bring level up evenly in all parts of forms.
 - a. After placement begins, continue without significant interruption and as a continuous operation until the end of that placement is reached.
 - b. Do not allow "cold joints" to form between adjacent layers or areas of the placement, or initial set to form on "wet edge" of placements.
 - c. Take precautions to prevent delays between placement of adjacent layers or areas from exceeding 20 minutes.
 - 1) If more than 20 minutes have elapsed since the initial surface was placed, spread a layer of neat cement grout, not less than 1/2 inch in thickness nor more than 1 inch in thickness, over the previously placed surface before depositing additional concrete.
 - 4. Placing concrete on slopes:
 - a. Commence placement at bottom of slope and work upward.

5. Placing horizontal concrete monolithically with structures below:
 - a. If concrete for slabs, beams, or walkways is to be cast monolithically with walls or columns below, do not place the horizontal concrete elements until the concrete in walls or columns below has been placed, consolidated, and allowed to achieve initial set.
 - 1) Allow set time of not less than 1 hour.
 - 2) Maintain a moist surface at the top of the walls or columns during the setting period.
 6. Placing a second concrete lift over hardened concrete below:
 - a. Take special precautions in form work at top of old lift and bottom of new lift to prevent:
 - 1) Spreading and vertical or horizontal displacement of forms.
 - 2) Grout "bleeding" onto finished concrete surfaces.
- D. Consolidating concrete:
1. Thoroughly consolidate concrete into forms and around reinforcement, pipes, and other embeds using mechanical vibrators.
 - a. Take special care to place concrete solidly against forms, leaving no voids.
 - b. Make concrete solid, dense, compact, and smooth.
 2. Provide vibration energy sufficient to cause concrete to flow and readily settle into place leaving no voids.
 - a. Vibration should visibly affect concrete over a radius of at least 18 inches without segregation.
 3. Vibrators:
 - a. At all times, have sufficient vibrators on hand to consolidate concrete as it is placed.
 - b. In addition to vibrators in use while concrete is being placed, have on hand at least 1 spare vibrator in serviceable condition.
 - c. Place no concrete until it has been ascertained that all vibrating equipment, including spares, are in serviceable condition.
- E. Finishing concrete:
1. Provide concrete finishes specified in Section 03366 Tooled Concrete Finishes.
 2. Liquid evaporation retardant:
 - a. Where conditions will result in rapid evaporation of moisture from the surface of the fresh concrete during finishing operations, use evaporation retardant.
 - 1) Such conditions include low humidity, high heat, and wind occurring alone or in combination.
 - b. Immediately after the concrete is screeded, coat the surface of the concrete with a liquid evaporation retardant.
 - 1) Apply the evaporation retardant again after each work operation as necessary to prevent drying shrinkage cracks and crazing at the surface.

3.06 CURING AND PROTECTING CONCRETE

- A. Curing concrete:
1. Cure concrete by methods specified in this Section.

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- a. Maintain the designated level of curing for a minimum of 7 days after placement, unless the details of a particular method specify a longer period.
 - 1) Make provisions to maintain moisture or curing membrane integrity at edges of slabs, tops of walls, and joint surfaces, and to prevent loss of protection.
2. Schedule of curing methods:
 - a. Concrete surfaces that will receive additional materials that require bond to the initial placement (including concrete; coatings, paints, sealers; grout, and other materials):
 - 1) Water curing or plastic membrane curing.
 - b. Formed surfaces:
 - 1) If non-absorbent forms are left in place for 7 days after placement: No additional requirements.
 - 2) For absorbent forms or when forms are removed during the 7 days following placement: Cure by water curing, plastic membrane curing, or sprayed membrane curing.
 - c. Unformed concrete surfaces:
 - 1) Water curing, plastic membrane curing, or sprayed membrane curing.
3. Water curing:
 - a. Keep surfaces of concrete constantly and visibly moist to saturated by ponding, continuous fogging, or continuous sprinkling at all times during curing period.
 - 1) Cover surfaces if required to maintain moist conditions.
 - 2) For horizontal slabs, pond the surface with at least 2 inches of water or cover with saturated mats or fabric kept continuously wet.
 - b. Formed surfaces: Each day forms remain in place may be counted as 1 day of water curing.
 - 1) Do not loosen form ties while concrete is being cured by form left in place.
 - 2) No further credit for curing time will be allowed after contact between the concrete surface and the forms has been broken.
4. Plastic membrane curing:
 - a. Cover concrete with plastic membrane, sealing joints and edges against displacement by wind or site operations and to prevent loss of moisture.
 - b. Install plastic membrane as soon as concrete is finished and can be walked on without damage.
 - c. Keep all surfaces of concrete under plastic membrane moist at all times during the curing period.
5. Sprayed membrane curing:
 - a. Application of curing compound:
 - 1) Apply curing compound to concrete surface after repairing and patching, and within 1 hour after forms are removed.
 - a) If more than 1 hour elapses after removal of forms, do not use sprayed membrane curing, but use water curing for full curing period.
 - 2) CONTRACTOR is cautioned that the method of applying curing compound specified in this Section may require more compound than normally suggested by manufacturer of compound, and also more than is customary in the trade.

- 3) Apply curing compound by mechanical, power-operated sprayer with mechanical agitator that will uniformly mix all pigment and compound.
 - 4) Apply compound in at least 2 coats.
 - 5) Apply each coat in a direction turned 90 degrees from the preceding coat.
 - 6) Apply curing compound in sufficient quantity that concrete has uniform appearance and that the natural color of the concrete is effectively and completely concealed at time of spraying.
 - 7) Continue to coat and recoat surfaces until specified coverage is achieved and until coating film remains on concrete surfaces.
 - 8) Provide compound having a film thickness that can be scraped from surfaces at any and all points after drying for at least 24 hours.
 - 9) Take care to apply curing compound to edges of placements and in areas of construction joints.
 - a) See that curing compound is placed over the full profile of construction joint surface.
- b. Removal of curing compound:
- 1) Do not remove curing compound from concrete in less than 7 days.
 - a) During this period, the CONTRACTOR may remove curing compound only after receiving ENGINEER'S acceptance of written request to do so.
 1. Include with the request the measures that will be provided to adequately cure surfaces where curing compound has been removed.
 - 2) Before placing fresh concrete against a surface previously coated with curing compound, remove the curing compound by heavy sandblasting.
 - 3) Prior to final acceptance of the work, remove any curing compound on surfaces exposed to view by sandblasting or other acceptable method, so that only natural color of finished concrete is visible and uniform over the entire surface.

B. Protecting concrete:

1. Immediately after placement, protect concrete from drying, hot or cold weather, and mechanical damage.
2. Temperature:
 - a. Cold weather: Protect concrete during the curing period so that the concrete temperature is maintained within the following requirements.
 - 1) Sections less than 12 inches thick: Minimum 55 degrees Fahrenheit.
 - 2) Sections 12 to 36 inches thick: Minimum 50 degrees Fahrenheit.
 - b. Hot weather: Protect concrete during the curing period so that the concrete temperature does not exceed 90 degrees Fahrenheit.
 - c. Remove protection against temperature gradually so that concrete surface temperature does not drop or rise by more than 40 degrees Fahrenheit during any 24 hour period.
3. Maintain forms, shoring, and bracing in place after concrete placement for a periods after concrete placement as indicated in the following paragraphs. Forms

may be removed after these periods if the concrete has developed sufficient strength and hardness to resist surface or other damage.

a. Vertical forms:

- 1) General: Minimum 24 hours after concrete placement.
- 2) Sides of footings: Minimum 24 hours after concrete placement.
- 3) Sides of beams, girders, and similar members: Minimum 48 hours after concrete placement.

b. Horizontal forms:

- 1) Slabs, beams, and girders: Until concrete reaches specified compressive strength, f'_c , or until shoring is installed.

c. Shoring for slabs, beams, and girders:

- 1) Shore until concrete strength reaches specified compressive strength, f'_c .
 - a) Temporary shoring may be required after the specified compressive strength is reached if construction loads will exceed the designated live load capacity of the structure.

d. Wall bracing:

- 1) Brace until strength of concrete beams and slabs laterally supporting the wall reaches specified compressive strength, f'_c .

4. Loads against or on the concrete:

a. Loading of "green" concrete, by backfilling or by personnel or equipment placed on the surface, is not permitted.

- 1) Green concrete: Defined as concrete whose current compressive strength is less than 100 percent of the specified compressive strength, f'_c .

b. Backfilling: Do not place backfill against concrete walls until the wall and all elements attached to it, including connecting slabs or beams, are fully braced by the structure, and have achieved their specified compressive strength, f'_c .

3.07 JOINTS AND JOINT PREPARATION

A. Joint locations and details:

1. Construct concrete work as monolith to the extent practical.
2. Construct joints as indicated on the Drawings and as specified.
3. Locations of construction, expansion, and other joints are indicated on the Drawings or specified in this Section.
 - a. Do not relocate, add, or delete joints without prior approval from the ENGINEER.

B. General:

1. Keyways in joints:
 - a. Provide keyways in joints where indicated on the Drawings.
 - b. Treat lumber keyway material with form release coating, applied in accordance with manufacturer's instructions.

C. Construction joints:

1. Where spacing is not indicated on the Drawings, provide construction joints in slabs and walls at intervals not greater than 35 feet.
2. Construct as indicated on the Drawings.

- a. Before placing fresh concrete against the joint: Use heavy sandblast to thoroughly clean joint surfaces and reinforcement crossing the joint of laitance, grease, oil, mud, dirt, curing compounds, mortar droppings, or other objectionable matter.
 - b. Just before placing concrete against the joint, wash surface with water to saturate joint surface and concrete surfaces within 12 inches of the joint.
 - c. Horizontal joints:
 - 1) Immediately before placing concrete, thoroughly spread bed of neat cement over the joint surface.
 - 2) Grout thickness: Not less than 1/2 inch, nor more than 1 inch.
- D. Expansion joints:
- 1. Where width is not indicated on the Drawings, provide 3/4-inch wide joint.
 - 2. Construct as indicated on the Drawings.
 - 3. Do not extend through expansion joints reinforcement, conduits, or other items unless details for such crossings are indicated on the Drawings.
 - 4. Preformed expansion joint material:
 - a. Accurately position joint filler in the joint and fasten to concrete or forms with adhesive.
 - b. Tape splices in joint filler to prevent intrusion of mortar.
 - 1) Fastening joint filler using nails, bolts, screws, or similar items is not permitted.

3.08 TOLERANCES

- A. Concrete:
- 1. Finished concrete: Conform to shapes, lines, grades, and dimensions indicated on the Drawings.
 - 2. In accordance with ACI 117, except as modified in the following paragraphs:
 - a. Slabs where slope is indicated:
 - 1) Uniformly slope to drain.
 - 2) Provide slabs without depressions that puddle water.
 - b. Slabs indicated to be level: Maximum deviation of 1/8 inch in 10 feet without any apparent changes in grade.
- B. Embeds:
- 1. General:
 - a. Sleeves and inserts: Plus 1/8 inch.
 - b. Projected ends of anchor bolts: From 0 to 1/4 inch.
 - c. Anchor bolt position: Plus 1/16 inch.
 - 2. Equipment: Set inserts to tolerances required for proper installation and operation of equipment or systems to which insert pertains.

3.09 FIELD QUALITY CONTROL

- A. Field testing of concrete:
- 1. During progress of construction, the OWNER will perform testing to determine whether the concrete, as being produced, complies with requirements specified.
 - a. Cost of this testing will be borne by the OWNER.

2. Program for sampling and testing:
 - a. Sample concrete in accordance with ASTM C 172.
 - b. Slump: Test for slump in accordance with ASTM C 143.
 - 1) Test slump at the beginning of each placement, as often as necessary to keep slump within the specified range, and when requested to do so by the ENGINEER.
 - c. Compressive strength, f'_c : Make and cure test specimens in accordance with ASTM C 31: Test for compressive strength in accordance with ASTM C 29.
 - 1) Prepare and test not less than 3 cylinder specimens, 6 inch diameter by 12-inches long, for each test.
 - a) One cylinder will be broken at 7 days and 2 cylinders will be broken at 28 days.
 - 2) Prepare and test cylinders according to the following schedule:
 - a) Minimum of 1 set of cylinders for each 150 cubic yards of each class of concrete.
 - b) Minimum of 1 set of cylinders for each class of concrete for each half-day of placement.
 - d. Air entrainment: Test for air entrainment in accordance with ASTM C 173.
 - 1) Test percent of entrained air in concrete at the beginning of each placement, as often as necessary to keep entrained air within the specified range, and when requested to do so by the ENGINEER.
 3. The CONTRACTOR shall:
 - a. Furnish concrete for test specimens, and provide manual assistance to the ENGINEER in preparing said specimens.
 - b. Assume responsibility for providing care and on-site curing and protection for test specimens in accordance with ASTM C 31.
- B. Enforcement of specification requirements:
1. Do not place concrete that does not conform to the requirements of these Specifications.
 - a. Remove such materials from the site.
 2. Strength requirements:
 - a. Concrete is expected to reach higher compressive strength than that which is indicated in Table A as specified compressive strength f'_c .
 - b. Concrete strength will be considered acceptable if following conditions are satisfied:
 - 1) Averages of all sets of 3 consecutive strength test results are greater than or equal to specified compressive strength f'_c .
 - 2) No individual strength test (average of 2 cylinders tested at 28 days) falls below specified compressive strength f'_c by more than 500 pounds per square inch.
 - c. Whenever 1 or both of the conditions stated above is not satisfied, provide additional curing or testing of the affected portion as directed by the ENGINEER.
 - 1) The costs of such curing or testing shall be at the CONTRACTOR'S expense.

3.10 ADJUSTING

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

END OF SECTION

SECTION 03366
TOOLED CONCRETE FINISHES

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 hardwood 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.
- 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. Basin bottoms, to which layer of grout is to be applied.
 - b. Projecting footings, which are to be covered with dirt.
 - c. 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.

END OF SECTION

03366-4

SECTION 03371

SHOTCRETE

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Shotcrete.
- B. Related Sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the CONTRACTOR'S responsibility for scheduling and coordinating the work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR'S work.
 - 3. The following sections are related to the work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed work complies accurately with the Contract Documents.
 - a. Section 02100 - Site Preparation.
 - b. Section 03150 - Concrete Accessories.
 - c. Section 03300 - Cast-In-Place Concrete.
 - d. Section 03366 - Tooled Concrete Finishes.
 - e. Section 07900 - Joint Sealants.

1.02 REFERENCES

- A. American Concrete Institute (ACI):
 - 1. 301 - Specifications for Structural Concrete.
 - 2. 308 - Standard Practice for Curing Concrete.
 - 3. 305R - Guide to Hot Weather Concreting.
 - 4. 306R - Guide to Cold Weather Concreting.
 - 5. 315 - Details and Detailing of Concrete Reinforcement.
 - 6. 318 - Building Code Requirements for Structural Concrete.
 - 7. 506R - Guide to Shotcrete.
 - 8. 506.2 - Specification for Materials, Proportioning, and Application of Shotcrete.
 - 9. 544.3R - Guide for Specifying, Proportioning, and Production of Fiber-Reinforced Concrete.
- B. ASTM International (ASTM):
 - 1. A 185 - Specification for Steel Welded Wire Reinforcement, Plain, for Concrete.
 - 2. A 497 - Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete.
 - 3. C 33 - Standard Specification for Concrete Aggregates.

4. C 39 - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
5. C 42 - Standard Test Method of Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
6. C 94 - Standard Specification for Ready-Mixed Concrete.
7. C 127 - Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate.
8. C 128 - Standard Test Method for Relative Density (Specific Gravity) and Absorption of Fine Aggregate.
9. C 136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
10. C 138 - Density, Yield and Air Content of Concrete.
11. C 150 - Standard Specification for Portland Cement.
12. C 157 - Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete.
13. C 185 - Standard Test Method for Air Content of Hydraulic Cement Mortar
14. C 192 - Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory.
15. C 231 - Test Method for Air Content of Freshly Mixed Concrete by Volumetric Method.
16. C 260 - Standard Specification for Air-Entraining Admixtures for Concrete.
17. C 311 - Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland-Cement Concrete.
18. C 615 - Standard Specification for Granite Dimension Stone.
19. C 618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
20. C 642 - Standard Test Method for Density, Absorption, and Voids in Hardened Concrete.
21. C 1141 - Specification for Admixtures for Shotcrete.
22. C 1218 - Standard Test Method for Water-Soluble Chloride in Mortar and Concrete.
23. D 75 - Standard Practice for Sampling Aggregates.
24. D 2103 - Standard Specification for Polyethylene Film and Sheeting.

1.03 DEFINITIONS

- A. Dry-Mix Shotcrete: Shotcrete in which most of the mixing water is added at the nozzle.
- B. Shotcrete: Mortar or concrete pneumatically projected at high velocity onto a surface.
- C. Wet-Mix Shotcrete: Shotcrete in which all ingredients, including water, are mixed before introduction into the delivery hose; compressed air is introduced to the material flow at the nozzle.

1.04 SYSTEM DESCRIPTION

- A. General Requirements
 1. Shotcrete may be applied using either the wet-mix or dry-mix method. Shotcrete may be applied with an automated system acceptable to the ENGINEER. All

- shotcrete shall be accurately formed, properly placed, and finished as specified herein.
2. The CONTRACTOR shall inform the DISTRICT at least five working days prior to the placement of shotcrete.
- B. Governing Standards: Shotcrete shall comply with the recommendations of ACI 506R, "Guide to Shotcrete", and the requirements of ACI 506.2, "Specification for Materials, Proportioning, and Application of Shotcrete", except as otherwise specified.
- C. Workers' Qualifications:
1. Workers, including the foreman, nozzleman, and delivery equipment operator, shall be fully qualified to perform the work. The nozzleman shall have had a minimum of 2 years of recent experience on similar structural shotcrete work and shall be certified in accordance with ACI CP-60.
 2. The shotcrete equipment system shall be of a design and size that has given satisfactory results on similar work in the last five years. At the time of the bid, the CONTRACTOR shall have a minimum of two operable shotcrete equipment systems available that have been used to achieve satisfactory results. The shotcrete equipment system used shall be capable of discharging mixed materials into the hose under close control and shall be able to deliver a continuous smooth stream of uniformly mixed material at the proper velocity to the discharge nozzle, free from any slugs.

1.05 SUBMITTALS

- A. All submittals of drawings; mix design; manufacturers' certificates of compliance, recommendations, and test data; reports; catalog data sheets; and other data shall be submitted to the ENGINEER in accordance with Section 01330, Submittal Procedures.
- B. Proposed Mix Design: Reports and certifications on proposed materials and mix proportions for each concrete mix design shall be submitted for review within 10 days after the preconstruction conference and prior to conducting the laboratory trial batches for the mix design. The report for each shotcrete mix submitted shall contain the following information:
1. Total gallons of water per cubic yard.
 2. Brand, size, and quantity of fibers.
 3. Brand, type, composition, and quantity (volume and weight) of cement.
 4. Source, class, composition, and quantity of fly ash, if used.
 5. Specific gravity and gradation of each aggregate, as furnished, in accordance with ASTM C 33. Reports for fine aggregate shall include source and type, gradation and fineness modulus, deleterious substances, water-soluble chloride ion, and sand equivalent. Reports for coarse aggregate shall include source and type, gradation and abrasion loss, deleterious substances, results of sodium or magnesium sulfate soundness test, and water-soluble chloride ion.
 6. Absorption of shotcrete.
 7. Volume and weight (saturated surface dry) of each aggregate per cubic yard.
 8. Brand, type, ASTM designation, active chemical ingredients, and quantity of each admixture, if any.
 9. Air content.

10. Water-soluble chloride ion for each aggregate and each mix design.
11. Compressive strength required and strength achieved at 7 and 28 days.

All tests and reports required for preliminary review shall be made by an independent testing laboratory at the expense of the CONTRACTOR.

C. Drawings and Data:

1. Data describing the equipment to be used for proportioning, mixing, and transporting concrete, including compressed air equipment and proposed arrangement and capacity, shall be submitted. In the case of ready-mixed concrete, certification that the ready-mix plant complies with the requirements of ASTM C 94 will be acceptable.
2. Samples of concrete materials; product data; and manufacturer's installation instructions for joint materials, admixtures, repair materials, sealers, and hardeners shall be submitted.
3. Procedures for hot and cold weather shotcreting shall be submitted when such conditions are anticipated.
4. Bar lists and drawings for the fabrication and placing of reinforcement shall be submitted for review and shall have sufficient plans, elevations, and sections to adequately detail and label all reinforcement. The bar lists and drawings shall also include a reference to the structure in which the reinforcement will be installed and to the project drawing showing the reinforcement.

- D. Manufacturer's Certificate of Compliance: A manufacturer's certificate of compliance, which includes the name of the project and, when requested, copies of independent test results confirming compliance with specified requirements, shall be submitted to the ENGINEER of cement, steel reinforcement, admixtures, and fly ash.

1.06 STORAGE OF MATERIALS

- A. Cement and fly ash shall be stored in suitable moisture-proof enclosures. Cement and fly ash which have become caked or lumpy shall not be used and shall be replaced at the expense of the CONTRACTOR.
- B. Aggregates shall be stored so that segregation and the inclusion of foreign materials are prevented. The bottom 6 inches of aggregate piles in contact with the ground shall not be used.

1.07 QUALITY ASSURANCE

- A. The shotcrete applicator shall submit through the CONTRACTOR a satisfactory experience record including references from the previous application of the specified materials to structures of similar design and complexity.

PART 2 PRODUCTS

2.01 LINING REQUIREMENTS FOR MIX DESIGN

- A. Concrete materials shall be selected and concrete shall be proportioned, placed, and cured in a manner that will minimize shrinkage and cracking as specified herein and in accordance with ACI 544.3R. Concrete temperatures shall be controlled both before and after placement to minimize cracking. Any rise in concrete temperature caused by environmental conditions that will be conducive to excessive shrinkage shall be controlled with blankets or other acceptable means of insulation.
- B. Cement Content: Cement content for dry-mix shotcrete shall be mixed as listed in ACI 506R. Cement content for wet-mix shotcrete shall be at least 705 pounds per cubic yard (7.5 sacks).
- C. Fly Ash Content: At the option of the CONTRACTOR, fly ash may be substituted for up to 15 percent of the Portland cement on the basis of 1.5 pounds of fly ash added for each pound of cement reduction.
- D. Fine Aggregate: Fine aggregate shall be well graded, with a fineness modulus of 2.50 to 2.90.
- E. Maximum Water-Cement Ratio: The maximum water-cement ratio shotcrete shall be 0.40 on a weight (mass) basis, or, if fly ash is used for wet-mix shotcrete, the combined mass of cement plus fly ash shall be used to determine the water-cementations materials ratio.
- F. Total Air Content (wet-mix shotcrete only): The total volumetric air content of wet-mix shotcrete delivered shall be 6 percent plus or minus 1 percent.
- G. Compressive Strength: Minimum compressive strength at 28 days, as determined by ASTM C 42, shall be 4,000 psi. The minimum compressive strength at 7 days shall be 3,000 psi.
- H. Admixtures: The admixture content, batching method, and time of introduction to the mix, when used, shall be in accordance with the manufacturer's recommendations for minimum shrinkage for compliance with these specifications.
- I. Fiber Concrete: Structural fibers shall be added to the concrete materials at the time the materials are batched for the concrete at the rate of 1.5 pounds per cubic yard. Fiber length shall be two inches. Batching and mixing procedures shall be in accordance with the manufacturer's recommendations. Fibers shall be randomly oriented and uniformly distributed throughout the concrete.
- J. Proportions: Shotcrete proportions shall be one part cement to not more than four parts fine aggregate by weight.

2.02 ACCESSORIES

A. Accessories shall comply with Section 03150 Concrete Accessories.

2.03 MATERIALS

A. All materials for shotcrete shall conform to the following requirements:

Item	Requirement
Portland Cement	ASTM C 150, Type II or III, low alkali.
Coarse Aggregate	ASTM C 33 and combined aggregate gradation limits in ACI 506R
Water	Clean and free from deleterious substances meeting the requirements of ASTM C 94
Admixtures	ASTM C 1141, Type I for dry-mix shotcrete, Type II for wet-mix shotcrete. See admixture requirements in Section 03300 Cast-in-Place Concrete.
Fibers	2" structural fibers
Polyethylene Film	ASTM C 171, white, thickness not less than 0.0040 (ASTM D 2103)
Membrane Curing Compound	See membrane curing compound requirements in Section 03300 Cast-in-Place Concrete
Reinforcement	Welded-wire reinforcement (mesh)
ASTM A 185 or A 497	CRSI Class 1, plastic protected; or Class 2, stainless steel protected.
Joint Sealants	Section 07900 Joint Sealants
Fly Ash (Wet-mix shotcrete)	ASTM C 618, Class F, except loss on ignition shall not exceed 4 percent.
Air-Entraining Agent (Wet-mix shotcrete)	ASTM C 260; Grace "Darex AEA", Master Builders "MB-AE-10", Sika Chemical "AER", or approved equal.

2.04 REINFORCEMENT

A. Reinforcement shall be accurately formed and shall be free from loose rust, scale, concrete splatter, and contaminants which reduce bond. Unless otherwise indicated

on the drawings or specified herein, the details of fabrication shall conform to ACI 315 and ACI 318. Welding or tack welding of reinforcement shall not be permitted.

2.05 BATCHING AND MIXING

- A. Shotcrete shall be furnished by an acceptable supplier.
- B. Batching and mixing shall conform with ASTM C 94. Dry-mix shotcrete shall be shot within 45 minutes after batching and wet-mix shotcrete material shall be shot within 90 minutes after batching.
- C. Consistency: The consistency of shotcrete shall be suitable for the placement conditions.

2.06 PRELIMINARY TESTING

- A. CONTRACTOR shall submit the following preliminary tests:
 - 1. Cement: The CONTRACTOR shall supply the ENGINEER with certified copies of supplier's test reports showing chemical composition and physical analysis for each shipment delivered to the concrete supplier and certifying that the cement complies with ASTM C 150 and these specifications. The certificate shall be signed by both the CONTRACTOR and the concrete supplier.
 - 2. Water-Soluble Chloride: One test, performed in accordance with ASTM C 1218, shall be conducted on the shotcrete mix. Maximum water-soluble chloride ion concentrations in hardened shotcrete at an age of 28 days shall not exceed 0.10 percent by mass weight of cement. Test results shall be reported as the percent of chloride ions in the shotcrete and as a percent of chloride ion relative to the weight of cement in the shotcrete. Chloride testing of the shotcrete components, except aggregates, will be at the discretion of the CONTRACTOR. Copies of reports for such tests shall be furnished to the ENGINEER.
 - 3. Laboratory Shrinkage Limits: Based on modified ASTM C 157 test procedures, the shrinkage limits of concrete shall be the average drying shrinkage of each set of three test specimens cast in the laboratory from a trial batch as measured at the 21 days' drying age, and shall not exceed 0.036 percent.
 - 4. Aggregates: Aggregates shall not be sampled and tested in accordance with ASTM D 75 and C 136. In addition, the bulk specific gravity of each aggregate shall be determined in accordance with ASTM C 127 and ASTM C 128. Absorption testing of shotcrete shall be in accordance with ASTM C 642.
 - 5. Compression Test: Two compression test cylinders shall be made, one tested at 7 days and the other tested at 28 days in accordance with ACI 506.2. Test specimens shall be made, cured, and stored in conformity with ASTM C 192 and tested in conformity with ASTM C 39.
 - 6. Fly Ash: Fly ash shall be sampled and tested in accordance with ASTM C 618 and C 311. The CONTRACTOR shall supply the ENGINEER with certified copies of test reports provided by the SUPPLIER (source) showing chemical composition and physical analysis and certifying that the fly ash complies with the specifications. The certificate shall be signed by both the CONTRACTOR and the concrete supplier.

PART 3 EXECUTION

3.01 STORAGE AND HANDLING

- A. Reinforcing steel shall be carefully handled and protected from the elements and exposure to corrosion. Reinforcing steel shall be stored on supports that prevent the steel from touching the ground.

3.02 PREPARATION OF SURFACE

- A. The limits of each placement shall be predetermined by the CONTRACTOR and shall be acceptable to the ENGINEER. All shotcrete within such limits shall be placed in one continuous operation. Preparation and placement shall be as specified in ACI 506.2 unless otherwise specified.

Before shotcrete is placed, reinforcement and embedment shall be rigidly secured in proper position. All dirt, mud, water, organic material, and debris shall be removed from the space to be occupied by shotcrete. All surfaces encrusted with dried shotcrete and concrete from previous placement operations shall be cleaned. The entire installation shall be acceptable to the ENGINEER.

- B. Surface Preparation of Existing Concrete Surfaces:
 - 1. Prior to surface preparation, the lagoon shall be cleaned of debris in accordance with Section 02100 Site Preparation. All loose and deteriorated existing concrete shall be removed down to sound materials. All concrete surfaces shall be checked for delamination to ensure all concrete surfaces are sound.
 - 2. The CONTRACTOR shall remove, by sandblasting, grinding, wire brushing, or high-pressure water jets, all deteriorated, loose, unsound material, oil, grease, mud, laitance, contaminants, or other foreign material that may inhibit bonding of shotcrete. Areas to be repaired shall be chipped out to remove offsets causing abrupt changes in thickness. All edges shall be square cut to avoid feathered edges. The surface shall be dampened.
- C. Reinforcing Steel Treatment and Repair:
 - 1. Where corrosion or surface preparation activities have exposed reinforcing steel, the following procedure shall be used.
 - 2. Exposed reinforcing must be mechanically cleaned to remove all contaminants. If half the diameter of the reinforcing steel, or more, is exposed, chip out concrete behind the reinforcing steel a minimum of ½ inch for placement of repair material. Substrate shall have a fractured aggregate profile.
 - 3. Determine section loss and splice where loss exceeds 15 percent to 25 percent of the steel area.
 - 4. Abrasive blast all exposed steel surfaces to remove all contaminants and corrosion products.

3.03 PLACEMENT

- A. Shotcrete shall be placed in multiple layers, with each layer placed over the previous layer while the previous layer is still plastic. Shotcrete shall be placed with a minimum

air capacity that complies with ACI 506R and should be increased as needed for adequate shotcrete application. Shotcrete shall not sag or slough.

B. Reinforcement:

1. Reinforcement, including welded wire fabric, shall be accurately positioned on supports, spacers, hangers, or other reinforcement, and shall be secured in place with wire ties or suitable clips.
2. With the exception of contact splices, the clear distance between parallel bars shall not be less than 2-1/2 inches nor less than 3 bar diameters.
3. Before shotcrete is placed, reinforcement shall be rigidly secured in proper position. All surfaces encrusted with dried concrete from previous placements shall be cleaned and the entire installation shall be acceptable to the ENGINEER. Remove all frost and ice before concrete is placed.

C. Shotcreting

1. Particular care shall be taken during placement of shotcrete to maintain a uniform spray distance from the surface and to keep the nozzle as nearly perpendicular to the application surface as possible.
2. The shotcrete shall be applied to clean surfaces that have been prepared as specified and shall be compact, with no sand pockets.
3. At the edge of any section where the operations are temporarily suspended, the shotcrete shall be brought to a tapered edge, with taper extending back for not less than 12 inches.
4. Prior to placing the adjacent section, the surface of the tapered edge shall be cleaned by scraping and blowing away all rebound and washing down with air and water blast. No square joints will be permitted.
5. As the operation progresses, all rebound shall be kept out of the work. If the rebound does not fall clear of the work, it shall be removed by proper methods. No shotcrete shall be placed over rebound and in case of such condition arising, the CONTRACTOR shall remove, at his own expense, any shotcrete so placed. All rebound removed shall be discarded and shall not be included in batches.
6. Shotcreting shall be ceased immediately if excessive aggregate rebound and cement loss occur. Shotcrete shall not be placed during adverse weather conditions which may result in excessive moisture loss.
7. In cases where concrete is repaired in the vicinity of a contraction joint, the repairs shall be made to preserve the isolation between components on either side of the joint.
8. Chipping may be required where existing concrete bonds with new concrete.

- D. Cold Weather Shotcreting: Shotcrete shall not be placed in cold weather where the ambient temperature is below 40°F and falling, and when the shotcrete is likely to be subjected to freezing temperatures before gaining sufficient strength to avoid damage. Materials may be heated in order that the temperature of the shotcrete, when deposited, shall be not less than 50°F or more than 80°F. The temperature of the shotcrete shall be maintained in accordance with ACI 301 and the recommendations of ACI 306R. Shotcrete shall be protected in accordance with the recommendations of ACI 306R.

- E. Hot Weather Shotcreting: Shotcrete shall not be placed in hot weather when the ambient temperature is above 90°F and rising. Hot weather shotcreting shall be in accordance with the requirements of ACI 301 and the recommendations of ACI 305R. During periods of extremely hot weather, the placement schedule shall be arranged in a manner acceptable to the ENGINEER and shall provide time for the temperature of the previously placed coat to begin decreasing. The aggregate and mixing water shall be cooled to below 80°F.
- F. Low Humidity Shotcreting: Surfaces exposed to drying wind shall be water cured continuously from the time the shotcrete has taken initial set. Placement of shotcrete during periods of low humidity shall be in accordance with the requirements of ACI 301 and the recommendations of ACI 305R.

G. Thickness Control

Shotcrete thickness shall be controlled by the use of vertical and horizontal shooting wires. Shooting wires shall be installed under tension and spaced no more than 3 feet apart to establish uniform and correct shotcrete thicknesses. Wires of 18 to 20-gage diameter high tensile strength steel shall be used. Shooting wires shall be removed after shotcrete placement and shall not be embedded in the shotcrete surface. Shooting wires shall scribe the contour of the wall from top to bottom.

Prior to placement of shotcrete, the CONTRACTOR shall submit details of thickness control procedures and aids to the ENGINEER for review. During application of shotcrete coats, the CONTRACTOR shall demonstrate the effectiveness of his control procedures.

3.04 FINISHING

- A. Freshly placed shotcrete shall receive a smooth finish (S3 finish). See Section 03366 Tooled Concrete Finishes.

3.05 REPAIRING DEFECTIVE SHOTCRETE

- A. Porous shotcrete, sand pockets, “drummy” sounding shotcrete, and other defects shall be removed and replaced by the CONTRACTOR. Defects in shotcrete shall be repaired to the satisfaction of the ENGINEER at the expense of the CONTRACTOR. Shotcrete repair work shall conform with ACI 506.2.

Core holes shall be repaired in accordance with Article 5.3.7 of ACI 301. Core holes shall not be filled with shotcrete.

If newly placed shotcrete is subjected to rain that washes out cement or is damaged by ground water or storm runoff or otherwise makes the shotcrete unacceptable to the ENGINEER, the shotcrete layer in question shall be removed and replaced at the expense of the CONTRACTOR.

3.06 CURING

- A. Shotcrete shall be protected from loss of moisture for at least 7 days after placement. Curing of shotcrete shall be done by methods which will keep the concrete surfaces adequately wet for the specified curing period. See curing requirements in Section 03300 Cast-in-Place Concrete.

3.07 PROTECTION

- A. Shotcrete shall be protected from erosion due to rain by means of a sheet cover acceptable to the ENGINEER for a minimum of 7 days.

3.08 REMOVAL AND DISPOSAL OF EXCESS MATERIAL

- A. CONTRACTOR shall promptly, safely, and legally dispose of all excess material off the Project site.

3.09 FIELD QUALITY CONTROL TESTING

- A. At the discretion of the ENGINEER, field control tests required during the progress of the work may be made at the expense of the DISTRICT. The frequency specified for each field control test is approximate. If additional field control tests are necessary, in the opinion of the ENGINEER, all such tests shall be made.

A clearly defined pattern of continuous horizontal or vertical ridges or depressions at the reinforcing elements, after they are covered, will be an indication of insufficient cover or poor application and probable voids. In this case, the application of shotcrete shall be immediately suspended, and the work carefully inspected by the ENGINEER. Corrective measures, if any, shall be implemented and completed prior to resuming the shotcreting operations.

The shotcreting procedure may be corrected by adjusting the nozzle distance and orientation perpendicular to the surface or water content of the shotcrete mix. All overspray shall be removed from the surface. The shotcrete surface shall be broomed and roughened if needed to ensure proper bond.

B. Compression Tests

1. One set of four compression test cylinders shall be made each day shotcrete is placed. Two cylinders shall be tested at an age of 7 days and the remaining cylinders shall be tested at an age of 28 days. Test cylinders shall be at least 6 inches in diameter and have an L/D ratio of at least 2.
2. Each set of compression test cylinders shall be marked or tagged with the date and time of day the cylinders were made, the location in the work where the shotcrete represented by the cylinders was placed, the number of the delivery truck or batch, the air content, the slump, the unit weight, and the concrete temperature.
3. Compression tests will be evaluated in accordance with ACI 318.
4. Test reports shall be prepared in four copies and shall be distributed by the testing laboratory directly to the ENGINEER and the CONTRACTOR.

- C. Air Content: Air content shall be determined from each batch of concrete from which concrete compression test cylinders are made, in accordance with ASTM C 231 and verified in accordance with ASTM C 138.
- D. Shrinkage Tests: Shrinkage tests shall be performed once for each 50 cubic yards of shotcrete. Shrinkage testing shall be conducted as specified for the preliminary trial mixes. The average drying shrinkage of each set of test specimens measured at the 21 days drying age shall not exceed 0.048 percent.

END OF SECTION

SECTION 03462
PRECAST CONCRETE VAULTS

PART 1 GENERAL

1.01 DESCRIPTION

- A. This section includes materials, design, and installation of precast concrete vaults with factory applied waterproofing.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 01330 - Submittal Procedures.
- B. Section 02300 - Earthwork.
- C. Section 03300 - Cast-in-Place Concrete.

1.03 SUBMITTALS

- A. Submit submittal packages in accordance with Section 01330 Submittal Procedures.
- B. Submit manufacturer's catalog data on precast concrete items. Show dimensions of vault and location of openings including thicknesses of walls, floor, and top slab. Show reinforcing wire and steel. Show materials of construction by ASTM reference and grade.
- C. Submit manufacturer's design calculations and certification signed and sealed by a professional civil or structural engineer registered in the State of California that vault design and construction comply with the specified design load conditions and the referenced ASTM specification (e.g., ASTM C 857 and C 858).
- D. Submit manufacturer's catalog data, descriptive literature, and installation instructions for the waterproofing material.

1.04 INSPECTION

- A. The OWNER'S Representative or his authorized representative will conduct an inspection of the vault fabrication process at the manufacturer's plant prior to the placement of the concrete into the formwork. The inspection will review the quality of materials, the formwork, placement of reinforcing steel, location of openings in the vault, and other construction details as shown in the approved fabrication drawings in the submittal package. If the concrete is placed into the formwork without this prior inspection, the vault will be rejected.

- B. The OWNER'S Representative or his authorized representative will conduct a second inspection of the vault upon its arrival at the jobsite. The inspection will review the quality of the concrete surfaces, defects that indicate any imperfect concrete mixing and molding, surface defects indicated by honey-combed or open texture and damaged areas, any exposed or bare reinforcing steel, and waterproofing that is missing from indicated surfaces or poorly applied. If any of these items are present or exist, the vault will be rejected.

PART 2 MATERIALS

2.01 MANUFACTURERS

- A. Precast concrete vaults shall be manufactured by Jensen Precast, Utility Vault, Oldcastle Infrastructure, or approved equal.

2.02 PRECAST CONCRETE VAULTS

- A. Precast concrete vaults shall comply with ASTM C 858 except as modified herein.
- B. Design live and dead loads shall be in accordance with ASTM C 857. Design precast concrete vaults to withstand site soil conditions and traffic loading of A-16 per Table 1 of ASTM C 857 with a 30% increase due to impact. Soil lateral loads shall be as determined by ASTM C 857. Alternate design by the strength design method shall include a load factor of 1.7 times the lateral earth or hydrostatic pressures. Design shall evaluate earthquake (Zone 4).
- C. Design shall also comply with the following restrictions:
 - 1. The maximum reinforcement ratio allowed is one-half the reinforcement ratio that would produce a balanced strain condition.
 - 2. Earth pressure shall be converted to a horizontal pressure using a coefficient of earth pressure at rest of 0.5 and not a coefficient of active earth pressure.
 - 3. Include a live load surcharge of 2 feet of soil in the design of the walls.
- D. Precast vault construction shall be in the form of monolithic walls or horizontal wall sections; do not use panel walls.
- E. Minimum wall thickness shall be 6 inches. Design knockout wall panels to accommodate loading pressures defined above.
- F. Design and construct vaults to be watertight when subjected to groundwater over the entire height of the vault.
- G. Provide openings in precast vaults for piping and access. Provide cast in place inserts in the roof slab and end walls at the locations as shown on the Drawings. No field coring of openings is allowed.

2.03 PRECAST CONCRETE RISERS

- A. Precast concrete grade rings and cones shall comply with ASTM C 478, except that the wall thickness shall be 6 inches minimum. Provide interlocking keyways on rings and cones. Provide cones with cast in place inserts for the manhole frame.

2.04 SEALANTS AND MORTAR

- A. Fill joints between precast sections with a double layer of plastic sealing compound and make watertight. Plastic sealing compound shall comply with Federal Specification SS-S-00210. Fill with mortar all recesses, lifting inserts, or other cavities not filled with plastic sealing compound. Mortar shall comply with ASTM C 387, Type S.

2.05 CEMENT

- A. Cement shall be ASTM C 150, Type II.

2.06 ADMIXTURES

- A. Provide concrete admixtures as specified in Section 03300 Cast-in-Place Concrete.

2.07 WATERPROOFING

- A. The waterproofing material shall be Horn Dehydratine 4, Select Shield 301-A, or approved equal. The material is a black bituminous compound of brush or spray consistency for application on below grade concrete surfaces.

2.08 VAULT APPURTENANCES

- A. Provide ladders, covers and frames, vents, supports, inserts, eyebolts, and other miscellaneous metalwork as shown in the Plans.

PART 3 EXECUTION

3.01 EXCAVATING AND BACKFILLING FOR VAULTS

- A. Perform earthwork as specified in Section 02300 Earthwork. Provide 6-inch minimum thickness 3/4-inch crushed rock over the full width of the vault base and extend 12 inches beyond the edges of the vault. After repairing the waterproofing, backfill and compact around the vault with structural backfill material. Excavated material may be used for structural backfill provided it conforms to the Standard Specifications for structural backfill material.

3.02 INSTALLING VAULTS AND RISERS

- A. Set each precast concrete vault section or riser plumb on a double layer bed of sealant at least 1/2-inch thick to make a watertight joint with the preceding unit. Point the inside joint and wipe off the excess sealant.

3.03 WATERPROOFING

- A. Waterproofing shall be factory applied to all exterior surfaces of vaults and risers. This includes the bottom of the vault to be coated as an exterior surface. Apply two coats at a rate of 65 square feet per gallon per coat. Prior to backfilling, field apply waterproofing material on joints and damaged surfaces. Protect coating from damage during backfilling and compacting.

END OF SECTION

SECTION 03600

GROUTING

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Concrete mortar.
 - 2. Dry-pack mortar.
 - 3. Epoxy grout.
 - 4. Grout.
 - 5. Non-shrink epoxy grout.
 - 6. Non-shrink grout.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the CONTRACTOR'S responsibility for scheduling and coordinating the work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR'S work.
 - 3. The following sections are related to the work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed work complies accurately with the Contract Documents.
 - a. Section 03071 - Epoxies.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. C 109 - Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (using 2-inch or [50-millimeter] cube specimens).
 - 2. C 230 - Standard Specification for Flow Table for Use In Tests of Hydraulic Cement.
 - 3. C 531 - Standard Test Method for Linear Shrinkage and Coefficient of Thermal Expansion of Chemical-Resistant Mortars, Grouts, Monolithic Surfacing, and Polymer Concretes.
 - 4. C 579 - Standard Test Method for Compressive Strength of Chemical-Resistant Mortars, Grouts, and Monolithic Surfacing and Polymer Concretes.
 - 5. C 939 - Standard Test Method for Flow of Grout for Preplaced-Aggregate Concrete (Flow Cone Method).
 - 6. C 1107 - Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Non-shrink).
 - 7. C 1181 - Standard Test Methods for Compressive Creep of Chemical-Resistant Polymer Machinery Grouts.

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1.03 SUBMITTALS

- A. Non-shrink grout: Submit manufacturer's literature and certified test data prior to installation.
- B. Non-shrink epoxy grout: Submit manufacturer's literature and certified test data prior to installation.

1.04 DELIVERY, STORAGE, AND HANDLING

- A. All materials shall be delivered to the jobsite in their original, unopened packages or containers, clearly labeled with the manufacturer's product identification and printed instructions.
- B. All materials shall be stored in a cool dry place and in accordance with the manufacturer's recommendations.
- C. All materials shall be handled in accordance with the manufacturer's instructions.

1.05 PROJECT/SITE CONDITIONS

- A. Refer to manufacturer's literature or contact the manufacturer for any special physical or environmental limitations that may be required for use of products.

1.06 WARRANTIES

- A. Non-shrink grout: The manufacturer shall warranty that the non-shrink grout will never go below its initial placement volume when tested in accordance with ASTM C 1107.
- B. Non-shrink epoxy grout: The manufacturer shall warranty that non-shrink epoxy grout will show negligible shrinkage or expansion when tested in accordance with ASTM C 531.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Concrete mortar:
 - 1. General: Consist of concrete mixture with coarse aggregate removed and water quantity adjusted as required.
 - 2. At exposed concrete surfaces not to be painted or submerged in water: White cement.
- B. Dry-pack mortar:
 - 1. Consist of mixture of portland cement and sand.
- C. Epoxy grout:
 - 1. Consist of mixture of epoxy and sand.
 - 2. Sand: Clean, bagged, graded, and kiln dried silica sand.

D. Grout:

1. Consist of mixture of portland cement and sand.

E. Non-shrink epoxy grout:

1. Manufacturers: One of the following or equal:
 - a. Five Star Products, Inc., Fairfield, CT, Five Star Epoxy Grout.
 - b. BASF Construction Chemicals, Shakopee, MN, Masterflow 648 CP Plus.
 - c. L&M Construction Chemicals, Inc., EPOGROUT.
2. Non-shrink epoxy grout shall be a 100 percent solid, premeasured, prepackaged system containing a 2-component thermosetting epoxy resin and inert aggregate.
3. Consistency: Non-shrink epoxy grout shall maintain a flowable consistency for at least 45 minutes at 70 degrees Fahrenheit.
4. Dimensional stability (height change):
 - a. Non-shrink epoxy grout shall have negligible shrinkage or expansion (less than 0.0006-inches/inch) when tested in accordance with ASTM C 531.
5. Compressive strength: Non-shrink epoxy grout shall show a minimum compressive strength of 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 C 579, Method B.
6. Compressive creep: The compressive creep for non-shrink epoxy grout shall not exceed 0.0027-inches/inch when tested under 400 pounds per square inch constant load at 140 degrees Fahrenheit in accordance with ASTM C 1181.
7. Thermal capability: The coefficient of thermal expansion for non-shrink epoxy grout shall not exceed 0.000018-inches per inch per degree Fahrenheit when tested under ASTM C 531, Method B.

F. Non-shrink grout:

1. Manufacturers: One of the following or equal:
 - a. Five Star Products, Inc., Fairfield, CT, Five Star Grout.
 - b. BASF Construction Chemicals, Shakopee, MN, Masterflow 928.
 - c. L&M Construction Chemicals, Inc., Omaha, NE, CRYSTEX.
2. Preportioned and prepackaged cement-based mixture:
 - a. It shall contain no metallic particles such as aluminum powder and no metallic aggregate such as iron filings.
 - b. It shall require only the addition of potable water.
3. Potable water for pre-soaking, mixing, and curing: Clean and free of oils, acids, alkalis, organics, and any other deleterious matter.
4. Bleeding: Free from the emergence of mixing water from within or the presence of water on its surface.
5. In accordance with ASTM C 1107.
6. Consistency:
 - a. Remain at a minimum flowable consistency for at least 45 minutes after mixing at 45 degrees Fahrenheit to 90 degrees Fahrenheit when tested in accordance with ASTM C 230.
 - b. If at a fluid consistency, it shall be verified in accordance with ASTM C 939.
7. Dimensional stability (height change):
 - a. In accordance with ASTM C 1107, volume-adjusting Grade B or C at 45 degrees to 90 degrees.
 - b. It shall show 90 percent or greater bearing area under bases or baseplates.

8. Compressive strength: Non-shrink grout shall show minimum compressive strengths at 45 degrees Fahrenheit to 90 degrees Fahrenheit in accordance with ASTM C 1107 for various periods from the time of placement, including 5,000 pounds per square inch at 28 days when tested in accordance with ASTM C 109 as modified by ASTM C 1107.

2.02 MIXES

- A. Concrete mortar mix:
 1. Use water-to-cementitious materials ratio that is no more than that specified for concrete being repaired.
 2. 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.
- B. Dry-pack mortar mix: Use only enough water so that resulting mortar will crumble to touch after being formed into ball by hand.
- C. Epoxy grout:
 1. Mix in accordance with manufacturer's installation instructions.
 2. Proportioning:
 - a. For horizontal work: Consist of mixture of 1 part epoxy as specified in Section 03071 Epoxies with not more than 2 parts sand.
 - b. For vertical or overhead work: Consist of 1 part epoxy gel as specified in Section 03071 Epoxies with not more than 2 parts sand.
- D. Grout mix:
 1. For concrete repair: Mix in same proportions used for concrete being repaired, with only sufficient water to give required consistency for spreading.
 2. For spreading over the surfaces of construction or cold joints: Mix with no more water used than allowed by water-to-cementitious materials ratio specified for concrete.
 3. For other applications: Mix in proportions by weight of 1 part cement to 4 parts of concrete sand.
- E. Non-shrink epoxy grout: Mix in accordance with manufacturer's installation instructions.
- F. Non-shrink grout: 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 all loose material or foreign matter likely to affect the bond or performance of grout or mortar.

- B. Inspect baseplate and anchor systems for rust, oil, and other deleterious substances that may affect the bond or performance of grout.
- C. Confirm that newly placed concrete has been cured sufficiently to attain its design strength and limit further shrinkage.
- D. Verify that temperature of cementitious or epoxy grout does not exceed manufacturer's recommendations.

3.02 PREPARATION

- A. Surface preparation:
 - 1. Roughen all concrete surfaces by heavy sandblasting, chipping, or other mechanical means to assure bond.
 - a. Loose or broken concrete shall be removed.
 - 2. All grease, oil, dirt, curing compounds, laitance, and other deleterious materials that may affect bond that were identified in the inspection process shall be completely removed from concrete and bottoms of baseplates.
 - a. All metal surfaces should have a 2 to 3 mil peak-to-valley profile for epoxy grouts.
 - 3. For cementitious mortars and grouts, concrete shall be saturated surface damp.
 - a. Any standing water shall be removed prior to placing grouts.
 - 4. For epoxy grouts, do not wet concrete surfaces with water.
 - a. Instead, where required, wet surfaces with epoxy for horizontal work or epoxy gel for vertical or overhead work prior to placing epoxy grouts.
- B. Forms and headboxes for cementitious or epoxy grouts:
 - 1. Forms for grouts shall be built of material with adequate strength to withstand the placement of grouts.
 - 2. Forms must be rigid and liquid tight.
 - a. All cracks and joints shall be caulked with an elastomeric sealant.
 - b. All forms shall be lined with polyethylene for easy grout release.
 - c. Forms carefully waxed with 2 coats of heavy-duty paste wax shall also be acceptable.
 - 3. Forms shall be 4 to 6-inches higher than the baseplate on one side of the baseplate configuration when using head pressure for placement.
 - 4. A sufficient number of headboxes shall be built to facilitate placement of grouts.
 - 5. Air relief holes a minimum 1/8-inch in diameter shall be provided when required by a baseplate configuration to avoid entrapping air underneath.

3.03 APPLICATION

- A. Cement mortar and grout:
 - 1. For defective concrete repair:
 - a. Filling: Filling of voids around items through the concrete.
 - b. Grout spreading: Spread over construction joints, cold joints, and similar type items.
 - 2. Concrete surfaces:

- a. Apply epoxy-bonding agent to clean, roughened, and dry surfaces before placing mortar or grout.
- 3. Placing:
 - a. Exercise particular care in placing portland cement mortar or grout since they are required to furnish structural strength, or impermeable water seal, or both.
 - b. Do not use cement mortar or grout that has not been placed within 30 minutes after mixing.
- B. Epoxy grout:
 - 1. Apply in accordance with manufacturer's installation instructions.
 - 2. Use where specified herein or where indicated on the Drawings.

3.04 PLACEMENT

- A. Grout shall only be installed after the final equipment alignment is correct and accepted by the ENGINEER:
 - 1. Grouts shall be mixed in accordance with the manufacturer's recommendations.
 - 2. Use mortar mixer with moving paddles for mixing grouts. For cementitious grouts, pre-wet the mixer and empty out excess water before beginning mixing.
 - 3. Cementitious grouts:
 - a. Add non-shrink cementitious grout to a premeasured amount of water that does not exceed the manufacturer's maximum recommended water content.
 - b. Mix cementitious grouts per manufacturer's instructions for uniform consistency.
 - c. Grouts may be drypacked, flowed, or pumped into place.
 - 1) All baseplate grouting shall take place from one side of a baseplate to the other to avoid trapping air.
 - 2) Do not overwork grouts.
 - d. Do not retemper grout by adding more water after stiffening.
 - e. Hydrostatic head pressure shall be maintained by keeping the level of the grout in the headbox above the bottom of the baseplate.
 - 1) The headbox should be filled to the maximum level and the grout worked down to top of baseplate.
 - 4. Epoxy grouts:
 - a. Epoxy grouts shall be mixed in complete units.
 - 1) Do not vary the ratio of components or add solvent to change the consistency of the mix.
 - b. Pour the hardener into the resin and mix for at least 1 minute and until each mixture is uniform in color.
 - 1) Pour the chemical components into the mortar mixer wheelbarrow and add the aggregate.
 - 2) Mix until aggregate is uniformly wetted.
 - 3) Over mixing will cause air entrapment in the mix.
 - c. All epoxy grout shall be flowed into place using a headbox.
 - 1) All grouting shall take place from one side of a baseplate to the other in a continuous flow to avoid trapping air.
 - d. Hydrostatic head pressure shall be maintained by keeping the level of grout in headboxes above the bottom of baseplates.

- 1) Headboxes shall be filled to the maximum level and grout worked down to the bottom of baseplates.
- e. Epoxy grouts shall not be cut back after setting.
 - 1) The final level of grout will be as installed with all chamfer edges built into the formwork.

3.05 CURING

A. Cementitious grouts:

1. Grouts must be cut back to the lower edge of baseplates after reaching initial set.
 - a. Provide a 45-degree angle cut back.
2. Clean equipment and tools as recommended by the grout manufacturer.
3. Cure grouts in accordance with manufacturer's specifications and recommendations.
 - a. Keep grout moist for a minimum of 3 days.
 - b. The method needed to protect grouts will depend on temperature, humidity, and wind.
 - c. Wet burlap, a soaker hose, sun shading, ponding, and, in extreme conditions, a combination of methods shall be employed.
4. Grouts shall be maintained above 40 degrees Fahrenheit until they have attained a compressive strength of 3,000 pounds per square inch, or above 70 degrees Fahrenheit for a minimum of 24 hours to avoid damage from subsequent freezing.

B. Epoxy grouts:

1. Cure grouts in accordance with manufacturer's specifications and recommendations.
 - a. Do not wet cure epoxy grouts.
2. Consult the manufacturer for appropriate cure schedule. In no case should any surface in contact with epoxy grout be allowed to fall below 50 degrees Fahrenheit for a minimum of 48 hours after placement.

3.06 FIELD QUALITY CONTROL

- A. Non-shrink cementitious grouts shall be tested for 24-hour compressive strength in accordance with ASTM C 109.
- B. Non-shrink grouts shall be tested for 24-hour compressive strength in accordance with ASTM C 579, Method B.

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):
 - 1. D 638 - Standard Test Method for Tensile Properties of Plastics.
 - 2. D 695 - Standard Test Method for Compressive Properties of Rigid Plastics.
 - 3. D 790 - Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.

1.03 SUBMITTALS

- A. Product data: Submit manufacturer's data completely describing epoxy injection system materials.
- B. Quality control submittals:
 - 1. Certificates of Compliance.
 - 2. Manufacturer's Instructions.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Manufacturers: One of the following or equal:
 - 1. BASF Construction Chemicals, LLC, Concessive Standard LVI.
 - 2. Sika Chemical Corp., Sikadur 35, Hi Mod LV.
- B. Epoxy:
 - 1. Provide epoxy materials that are new and use them within shelf-life limitations set forth by manufacturer.
 - 2. Water-insensitive 2-part type low viscosity epoxy adhesive material containing 100 percent solids and meeting or exceeding following characteristics when tested in accordance with standards specified:

Physical Characteristic	Test Method	Required Results
Tensile Strength	ASTM D 638	8,000 pounds per square inch at 14 days.
Flexure Strength	ASTM D 790	11,000 pounds per square inch at 14 days.
Compressive Strength	ASTM D 695	11,000 pounds per square inch at 24 hours.
Bond Strength	--	Concrete shall fail before failure of epoxy.
Gel Time for 5 Mil Film	--	4 hours maximum.
Elongation	ASTM D 638	1 percent minimum at 14 days.

2.02 EQUIPMENT

A. Pump unit:

1. Furnish unit to be used for injection that is positive displacement type with interlock to provide in-line mixing and metering system for 2 component epoxy.
2. Furnish pressure hoses and injection nozzle of such design as to allow proper mixing of 2 components of epoxy.
3. Presence of standby injection unit may be required.

2.03 MIXES

A. Epoxy injection system materials:

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.

PART 3 EXECUTION

3.01 PREPARATION

A. Surface preparation:

1. Epoxy injection system:
 - a. General: Before processing, sweep or clean area in vicinity of crack location to receive epoxy and leave in generally clean condition.
 - b. Joints to receive epoxy: Clean in manner such that joints 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. Perform and conduct work of this Section in neat, orderly manner.
- C. Epoxy injection system:
 1. Apply adequate surface seal to crack or joint to prevent escape of epoxy.

2. Establish entry points at distance along seal not less than thickness of cracked member.
3. Force epoxy into crack at first port with sufficient pressure to advance epoxy to adjacent port.
4. Seal original port and shift entry to port at which epoxy appears.
5. Continue this manner of port-to-port injection until each joint has been injected for its entire length.
6. For small amounts, or where excessive grout pressure developed by pump unit might further damage structure, premixed material and hand caulking gun may be used if acceptable to the ENGINEER.
7. Seal ports, including adjacent locations where epoxy seepage occurs, as necessary to prevent drips or run out.
8. After epoxy injection is complete, remove surface seal material and refinish concrete in area where epoxy was injected to match existing concrete.

END OF SECTION

SECTION 05120

STRUCTURAL STEEL

PART 1 GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Structural steel shapes and plate.
 - 2. Fasteners:
 - a. All thread rods.
 - b. Anchor bolts.
 - c. Assembly bolts.
 - d. Chemical anchors.
 - e. Concrete anchors.
 - f. Eyebolts.
 - g. High strength bolts.
 - h. Powder actuated fasteners.
 - i. Sleeve anchors.
 - j. Welded studs.
 - 3. Isolation sleeves and washers.
 - 4. Thread coating.
 - 5. Welding.
- B. Related Sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the CONTRACTOR'S responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR'S Work.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 03055 - Epoxy Bonding Reinforcing Bars and All Thread Rods in Concrete.

1.02 REFERENCES

- A. American Institute of Steel Construction (AISC):
 - 1. Specification for Structural Steel Buildings.
- B. American National Standards Institute (ANSI):
 - 1. B212-15 - Cutting Tools - Carbide-tipped Masonry Drills and Blanks for Carbide-tipped Masonry Drills.

C. American Society for Testing and Materials (ASTM):

1. A 29 - Standard Specification for Steel Bars, Carbon and Alloy, Hot-Wrought, General Requirements.
2. A 36/A 36M - Standard Specification for Carbon Structural Steel.
3. A 53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc Coated, Welded, and Seamless.
4. A 108 - Standard Specification for Steel Bars, Carbon, Cold Finished.
5. A 123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
6. A 153/A 153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
7. A 240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
8. A 276 - Standard Specification for Stainless Steel Bars and Shapes.
9. A 307 - Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
10. A 325 - Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
11. A 489 - Standard Specification for Carbon Steel Lifting Eyes.
12. A 490 - Standard Specification for Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength.
13. A 496 - Standard Specification for Steel Wire, Deformed, for Concrete Reinforcement.
14. A 500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
15. A 501 - Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.
16. A 992/A 992M - Standard Specification for Structural Steel Shapes.
17. F 593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
18. F 959 - Standard Specification for Compressible-Washer-Type Direct Tension Indicators for Use with Structural Fasteners.

D. American Welding Society (AWS):

1. A 5.1 - Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding.
2. A 5.17 - Specification for Carbon Steel Electrodes and Fluxes for Submerged Arc Welding.
3. A 5.20 - Specification for Carbon Steel Electrodes for Flux Cored Arc Welding.
4. D 1.1 - Structural Welding Code - Steel.
5. D 10.4 - Recommended Practices for Welding Austenitic Chromium-Nickel Stainless Steel Piping and Tubing.

1.03 SUBMITTALS

A. Quality Control Submittals:

1. Submit shop drawings of members to be fabricated before starting their fabrication.
2. Welder's certificates.

B. 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.
2. Current International Code Council ES Report for chemical anchors.

1.04 QUALITY ASSURANCE

A. Qualifications:

1. Perform welding of structural metals with welders who have current American Welding Society certificate for the type of welding to be performed.
2. Steel fabricators shall be certified by the American Institute of Steel Construction (AISC) or other certification as recognized and accepted by the local building official having jurisdiction.
3. Notify ENGINEER 24 hours minimum before starting shop or field welding.
4. ENGINEER may check materials, equipment, and qualifications of welders.
5. Remove welders performing unsatisfactory Work, or require to requalify.
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.

1.05 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
Steel		
Plate, bars, rolled shapes (except W and WT shapes), and miscellaneous items	A 36	--
Rolled W and WT shapes	A 992	Grade 50
Hollow structural sections (HSS): round, square, or rectangular	A 500	Grade B
Tubing, hot-formed	A 501	--
Round HSS	A 500	Grade B
Steel pipe	A 53	Grade B
Stainless steel		
Plate, sheet, and strip	A 240	Type 304* or 316**
Bars and shapes	A 276	Type 304* or 316**
* Use Type 304L if material will be welded.		
** Use Type 316L if material will be welded.		

B. Where stainless steel is welded, use low-carbon stainless steel.

2.02 FASTENERS

- A. General: Furnish threaded fasteners, except high strength bolts, with flat washers, and self-locking nuts, or lock washers and nuts:
1. Bolt Heads and Nuts: Hex-type.
 2. Bolts, Nuts, and Washers: Of domestic manufacture.
 3. Where bolts, including anchor bolts, nuts, washers, and similar fasteners are specified to be galvanized, galvanize in accordance with ASTM A 153.

B. All Thread Rods:

1. Type 316 Stainless Steel in Accordance with ASTM F 593 for use in Wet and Moist Locations, Including:
 - a. Water-Containing Structures:
 - 1) Below and at water level.

- 2) Above Water Level:
 - a) Below top of walls of water-containing structures.
 - b) Under the roof, slab, beam, or walkway of enclosed water-containing structures.
 - 3) Dry side of walls of water-containing structures.
 - b. Pump bases.
 2. Type 304 or Type 316 stainless steel in accordance with ASTM F 593 for aluminum assemblies.
 3. ASTM A 36 meeting the mechanical requirements of ASTM A 307. Hot-dip galvanize for galvanized assemblies and for applications other than those specified.
- C. All Thread Rods Bonded in Holes Drilled in Concrete with Epoxy: As specified in Section 03055 Epoxy Bonding Reinforcing Bars and All Thread Rods In Concrete and as indicated on the Drawings.
- D. Anchor Bolts:
1. Anchor Bolts, Nuts, and Washers: Type 316 Stainless Steel in Accordance with ASTM F 593 for use in Wet and Moist Locations, Including:
 - a. Water-Containing Structures:
 - 1) Below and at water level.
 - 2) Above Water Level:
 - a) Below top of walls of water-containing structures.
 - b) Under the roof, slab, beam, or walkway of enclosed water containing structures.
 - c) Dry side of walls of water-containing structures.
 - b. Pump bases.
 2. Anchor Bolts, Nuts, and Washers: Type 304 or Type 316 stainless steel for fastening aluminum to concrete or steel.
 3. Anchor Bolts, Nuts, and Washers: Hot-dip galvanized ASTM A 307 steel bolt or hot-dip galvanized ASTM A 36 steel, for applications other than those specified.
- E. Assembly Bolts:
1. Bolts, Nuts, and Washers for Field-Assembled Construction: Type 316 stainless steel in accordance with ASTM F 593 for use in wet and moist locations, including:
 - a. Water-Containing Structures:
 - 1) Below and at water level.
 - 2) Above Water Level:
 - a) Below top of walls of water-containing structures.
 - b) Under the roof, slab, beam, or walkway of enclosed water containing structures.
 - c) Dry side of walls of water-containing structures.
 - b. Pump bases.
 2. Type 304 or Type 316 stainless steel in accordance with ASTM F 593 for aluminum assemblies.
 3. Hot-dip galvanized ASTM A 307 steel for galvanized assemblies and for applications other than those specified.
- F. Chemical Anchors:

1. Not allowed.
- G. Concrete Anchors:
1. Manufacturers: One of the following or equal:
 - a. Hilti Incorporated, Kwik Bolt TZ Anchor.
 - b. Simpson Strong Tie, Strong Bolt Wedge Anchor.
 2. Concrete Anchor's Integral Threaded Stud, Wedge, Washer, and Nut: Type 304 or Type 316 stainless steel in accordance with ASTM F 593. For use in wet and moist locations, including:
 - a. Water-Containing Structures:
 - 1) Below and at water level.
 - 2) Above Water Level:
 - a) Below top of walls of water-containing structures.
 - b) Under the roof, slab, beam, or walkway of enclosed water-containing structures.
 - 3) Dry side of walls of water-containing structures.
 - b. Pump bases.
 3. Concrete Anchor's Integral Threaded Stud, Wedge, Washer, and Nut: Type 304 or 316 stainless steel in accordance with ASTM F 593 for fastening aluminum to concrete or steel.
 4. Concrete Anchor's Integral Threaded Stud, Wedge, Washer, and Nut: Hot-dip galvanized carbon steel, for applications other than those specified.
 5. Do not use Slug-in, lead cinch, and similar systems relying on deformation of lead alloy or similar materials in order to develop holding power.
- H. Eyebolts:
1. Welded or forged, when manufactured of materials other than carbon steel.
 2. Having geometric and strength characteristics of eyebolts specified in ASTM A 489, Type 1. The strength characteristics include proof load requirements, breaking strength requirements, tensile strength requirements, bend test, and impact strength.
- I. Flush Shells:
1. Manufacturers: One of the following or equal:
 - a. ITW Red Head, Multi-Set II Drop-In.
 - b. Hilti Incorporated, HDI Drop-In.
 2. Bolts, Flush Shells, Threaded Rods, Washers, and Nuts: Type 303 stainless steel in accordance with ASTM F 593.
- J. High Strength Bolts: High strength bolts, nuts, and hardened flat washers shall be in accordance with ASTM A 325 or ASTM A 490, as indicated on the Drawings.
- K. Powder Actuated Fasteners:
1. For Installation in Concrete or Steel: Zinc coated, heat-treated, alloy steel.
 2. Fasteners Not Sufficiently Protected against Corrosion from Exposure to Corrosive Conditions: Coat as necessary to make suitable for such conditions.
 3. Pins: Furnish with head or threaded stud capable of transmitting loads to shank.
 4. Pins Connected to Steel: Furnish with longitudinal serrations around circumference of shank.

L. Sleeve Anchors:

1. Manufacturers: One of the following or equal:
 - a. Hilti Incorporated, HSL Heavy Duty Sleeve Anchor.
 - b. Simpson Strong Tie, Pleasanton, CA, Sleeve-All Sleeve Anchors
2. Use stainless material for aluminum and stainless attachments and carbon steel for steel attachments.
3. For use in wet and moist locations, including locations listed below. Use Type 304 stainless steel in accordance with ASTM F 593 for sleeve anchor's internal bolt, expansion sleeve, extension sleeve, and washer. Use Type 303 stainless steel in accordance with ASTM F 593 for sleeve anchors expansion cone.
 - a. Water-Containing Structures:
 - 1) Below and at water level.
 - 2) Above Water Level:
 - a) Below top of walls of water-containing structures.
 - b) Under the roof, slab, beam, or walkway of enclosed water-containing structures.
 - 3) Dry side of walls of water-containing structures.
 - b. Pump bases.
4. For fastening aluminum to concrete or steel, use Type 304 stainless steel in accordance with ASTM F 593 for sleeve anchor's internal bolt, expansion sleeve, extension sleeve. Use Type 303 stainless steel in accordance with ASTM F 593 for sleeve anchor's expansion cone.
5. For applications other than those specified above, use hot-dip galvanized carbon steel for sleeve anchor's internal bolt, expansion sleeve, expansion cone, extension sleeve, and washer.
6. The sleeve anchor shall have a nylon compression ring which compresses to ensure that the material being fastened is tightly secured against the concrete.
7. Do not use slug-in, lead cinch, and similar systems relying on deformation of lead alloy or similar materials in order to develop holding power.

M. Welded Studs:

1. ASTM A 108 with 50,000-pounds per square inch minimum yield strength, and 60,000-pounds per square inch minimum tensile strength.
2. Headed Studs: Manufacturers: One of the following or equal:
 - a. Nelson Stud Welding Company, S3L Shear Connectors or H4L Concrete Anchors.
 - b. Stud Welding Products, Headed Concrete Anchors or Shear Connectors.

2.03 ISOLATING SLEEVES AND WASHERS

A. Manufacturers: One of the following or equal:

1. Central Plastics Company, Shawnee, Oklahoma.
2. Corrosion Control Products, PSI Inc., Gardena, CA.

B. 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.

1. One sleeve required for each bolt.

- C. Washers: The inside diameter of all washer shall fit over the isolating sleeve and both the steel and isolating washers shall have the same inside diameter and outside diameter:
1. Proper size to fit bolts. Two insulating washers are required for each bolt.
 2. Two 1/8-inch thick steel washers for each bolt.
 3. G3 Phenolic:
 - a. Thickness: 1/8 inch.
 - b. Base Material: Glass.
 - c. Resin: Phenolic.
 - d. Water Absorption: 2 percent.
 - e. Hardness (Rockwell): 100.
 - f. Dielectric Strength: 450 volts per mil.
 - g. Compression Strength: 50,000 pounds per square inch.
 - h. Tensile Strength: 20,000 pounds per square inch.
 - i. Maximum Operating Temperature: 350 degrees Fahrenheit.

2.04 GALVANIZED SURFACE REPAIR

- A. Manufacturers: One of the following or equal:
1. Galvinox.
 2. Galvo-Weld.

2.05 THREAD COATING

- A. Manufacturers: One of the following or equal:
1. Never Seez Compound Corporation, Never-Seez.
 2. Oil Research, Inc., WLR No. 111.

2.06 SUPPLEMENTARY PARTS

- A. Furnish as required for complete structural steel erection, whether or not such parts and Work are specified or indicated on the Drawings.

2.07 FABRICATION

- A. Shop Assembly:
1. Fabricate structural steel in conformance with AISC "Specification for the Structural Steel Buildings - Allowable Stress Design and Plastic Design," 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. For Structural members such as W shapes, S shapes, channels, angles, and similar members not available in quantity, size, and type of stainless steel specified or indicated on the Drawings:
 - a. Fabricate by welding together pieces of low carbon stainless steel plate, such as Type 316L.
 - b. Make full penetration welds between pieces of plate to attain same or higher section modulus and moment of inertia as members indicated on the Drawings.

4. Where galvanizing is required, hot-dip galvanize structural steel after fabrication in accordance with ASTM A 123:
 - a. Do not electro-galvanize or mechanically-galvanize unless specified or accepted by ENGINEER.
 - b. Restraighten galvanized items that bend or twist during galvanizing.
5. Round off sharp and hazardous projections and grind smooth.
6. 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.
7. Take responsibility for correct fitting of all metal work.

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 cock out of alignment, redrill, reshape, 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 conformance with AISC "Specification for Structural Steel Buildings - Allowable Stress Design and Plastic Design," 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.
- 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 Stainless Steel:
 1. General: Comply with AWS D1.1.
 - a. Perform with electrodes and techniques in accordance with AWS D10.4.

D. Welding Carbon Steel:

1. General: Comply with AWS D1.1:

- a. Weld ASTM A 36 and A 992 structural steel, ASTM A 500 and A 501 structural tubing, and ASTM A 53 pipe with electrodes conforming to AWS A5.1, using E70XX electrodes; AWS A5.17, using F7X-EXXX electrodes; or AWS A5.20, using E7XT-X electrodes:

- 1) Field repair cut or otherwise damaged galvanized surfaces to equivalent original condition using a galvanized surface repair.

E. Interface With Other Products:

- 1. Where steel fasteners come in contact with aluminum or other dissimilar metals, bolt with stainless steel bolts and separate or isolate from dissimilar metals with isolating sleeves and washers:
 - a. Prior to installing nuts, coat threads of stainless steel fasteners with thread coating to prevent galling of threads.

F. Fasteners:

1. General:

- a. Install bolts, including anchor bolts and concrete anchors, to project 2 threads minimum, but 1/2 inch maximum beyond nut.
- b. Unless otherwise specified, tighten bolts, including anchor bolts and concrete anchors, to the "snug-tight" condition, defined as tightness attained by a few impacts of an impact wrench or the full effort of a man using an ordinary spud wrench.

2. All Thread Rods Bonded in Drilled Holes in Concrete with Epoxy: As specified in Section 03055 Epoxy Bonding Reinforcing Bars and All Thread Rods In Concrete and as indicated on the Drawings.

3. Anchor Bolts:

- a. Cast-in-place when concrete is placed.
- b. Accurately locate anchor bolts embedded in concrete with bolts perpendicular to surface from which they project.
- c. Do not allow anchor bolts to touch reinforcing steel.
- d. Where anchor bolts are within 1/4 inch of reinforcing steel, isolate with a minimum of 4 wraps of 10-mil polyvinyl chloride tape in area adjacent to reinforcing steel.
- e. In anchoring machinery bases subject to heavy vibration, use 2 nuts, with 1 serving as a locknut.
- f. Where bolts are indicated on the Drawings for future use, first coat thoroughly with nonoxidizing wax, then turn nuts down full depth of thread and neatly wrap exposed thread with waterproof polyvinyl tape.
- g. Furnish anchor bolts with standard hex bolt head or an equivalent head acceptable to ENGINEER unless otherwise indicated on the Drawings. "L" or "J" anchor bolts are not equivalent to an anchor bolt with a hex bolt head.
- h. Minimum Anchor Bolt Embedment: 10-bolt diameters, unless longer embedment is indicated on the Drawings.
- i. Where indicated on the Drawings, set anchor bolts in metal sleeves having inside diameter approximately 2 inches greater than bolt diameter and minimum 10-bolt diameters long. Fill sleeves with grout when a machine or other equipment is grouted in place.

- j. Anchor bolts may be cast in concrete in lieu of using concrete anchors.
- 4. Concrete Anchors:
 - a. Do not use concrete anchors in lieu of anchor bolts.
 - b. Accurately locate concrete anchors and set perpendicular to surfaces from which they project.
 - c. Minimum Embedment Lengths:

Diameter Inches	Embedment Length Inches
1/4	2
3/8	2-1/2
1/2	4-1/8
5/8	4-1/2
3/4	6-1/2

- d. Drilling Holes:
 - 1) Do not damage or cut existing reinforcing bars, electrical conduits, or other items embedded in the existing concrete without acceptance by ENGINEER.
 - 2) Determine location of reinforcing bars, or other obstructions with a non-destructive indicator device.
 - 3) Remove dust and debris from hole using compressed air.
- e. Hole Drilling Equipment:
 - 1) Electric or pneumatic rotary type with light or medium impact.
 - 2) Drill Bits: Carbide-tipped in accordance with ANSI B212-15.
 - 3) Hollow drills with flushing air systems are preferred.
 - 4) Where edge distances are less than 2 inches, use lighter impact equipment to prevent microcracking and concrete spalling during drilling process.
- 5. Deformed Bar Anchors:
 - a. Butt weld with automatic stud welding gun as recommended by manufacturer.
 - b. Ensure butt weld develops full strength of the anchor.
- 6. High Strength Bolts:
 - a. Consider connections with high strength bolts to be pretensioned type connections, unless otherwise indicated on the Drawings.
 - b. Connections with high strength bolts shall conform to AISC Specification for Structural Joints Using ASTM A 325 or A 490 Bolts.
 - c. Furnish Hardened Flat Washer:
 - 1) Under element, nut, or bolt head, turned in tightening.
 - 2) On outer plies for short slotted holes.
- 7. Powder Actuated Fasteners: Use powder actuated fasteners only for applications indicated on the Drawings or specified.
- 8. Sleeve Anchors:
 - a. Do not use sleeve anchors in lieu of anchor bolts.

- b. The sleeve anchor bolt shall be removable and the expansion sleeve shall be flush with the concrete surface when installed.
- c. Accurately locate sleeve anchors and set perpendicular to surfaces from which they project.
- d. Minimum Embedment Lengths:

Diameter Inches	Embedment Length Inches
1/4	1-3/4
3/8	2-1/2
1/2	3-1/2
5/8	4
3/4	4-1/2

- e. Drilling Holes:
 - 1) Do not damage or cut existing reinforcing bars, electrical conduits, or other items embedded in the existing concrete without acceptance by ENGINEER.
 - 2) Determine location of reinforcing bars, or other obstructions with a non-destructive indicator device.
 - 3) Remove dust and debris from hole using compressed air.

- f. Hole Drilling Equipment:
 - 1) Electric or pneumatic rotary type with light or medium impact.
 - 2) Drill Bits: Carbide-tipped in accordance with ANSI B212-15.
 - 3) Hollow drills with flushing air systems are preferred.
 - 4) Where edge distances are less than 2 inches, use lighter impact equipment to prevent microcracking and concrete spalling during drilling process.

- 9. Welded Studs:
 - a. Butt weld with automatic stud welding gun as recommended by the manufacturer.
 - b. Ensure butt weld develops full strength of the stud.

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.
 - 6. Related materials.

1.02 REFERENCES

- A. American Association of State Highway and Transportation Officials (AASHTO):
 - 1. M 198 - Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants.
- B. ASTM International (ASTM):
 - 1. C 920 - Standard Specification for Elastomeric Joint Sealants.
 - 2. D 412 - Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension.
 - 3. D 624 - Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomer.
- C. Federal Specification (FS):
 - 1. FS TT-S-00227e - Sealing Compound, Elastomeric Type, Multi-Component.

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.

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- 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 5 years in accordance with manufacturer's standard warranty.

PART 2 PRODUCTS

2.01 ACRYLIC-LATEX SEALANT

- A. Permanently flexible, nonstaining, and nonbleeding latex modified acrylic sealant compound, colors as selected by ENGINEER from manufacturer's standard options. Manufacturers: One of the following or equal:
 - 1. Tremco, Tremflex 834.
 - 2. Pecora Corp., Number AC 20.
 - 3. Sonneborn, Sonolac.

2.02 PRECAST CONCRETE JOINT SEALANT

- A. Preformed, cold-applied, ready-to-use, flexible joint sealant in accordance with ASTM C990 and AASHTO M 198. Manufacturers: One of the following or equal.
 - 1. Henry Corporation, Ram-Nek.
 - 2. Concrete Sealants Division, ConSeal.

2.03 SILICONE SEALANT

- A. ASTM C 920, Type S, Grade NS, Class 25, single component silicone sealant. Manufacturers: One of the following or equal:

1. Tremco, Proglaze.
2. Pecora Corp., Number 864.
3. Dow Corning, Number 795.
4. General Electric, Number 1200 Series.

2.04 SYNTHETIC RUBBER SEALING COMPOUND

- A. Manufacturer: One of the following or equal:
1. Sika Corporation, Lyndhurst, NJ, Sikaflex 2c NS or SL
 2. Polymeric Systems, Inc., PSI 275.
 3. Pacific Polymers, Garden Grove, CA, Elastothane 227R.
- B. Material: In accordance with ASTM C 920 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 rubber; able to perform satisfactorily when continuously submerged in water or sewage and exposed to direct sunlight in dry condition; with the following properties determined at 75 degrees Fahrenheit and 50 percent relative humidity:
1. Base: Polyurethane rubber.
 2. Solids: Minimum 97 percent.
 3. Application time: Minimum 2 hours.
 4. Cure time: Maximum 3 days.
 5. Tack free time: 24 hours.
 6. Ultimate hardness: Non-sag 25, Pourable/SL 40, within 5 Shore A.
 7. Tensile strength: Non-sag 120 pounds per square inch minimum and Self-leveling minimum 170 pounds per square inch when tested in accordance with ASTM D 412.
 8. Ultimate elongation: Minimum 490 percent when tested in accordance with ASTM D 412.
 9. Tear resistance: Non-sag 45 pounds per inch minimum and Self-leveling minimum 85 pounds per inch when tested in accordance with ASTM D 624, Die C.
 10. Service temperature range: Minus 25 degrees to 158 degrees Fahrenheit.
- C. Color: Gray to match concrete, unless indicated on the Drawings.

2.05 SYNTHETIC SPONGE RUBBER FILLER

- A. Closed-cell expanded sponge rubber manufactured from synthetic polymer neoprene base, or resilient polyethylene foam backer rod. Manufacturers: One of the following or equal:
1. Presstite, Number 750.3 Ropax Rod Stock.
 2. Rubatex Corp., Rubatex-Cord.
- B. Characteristics:
1. Suitable for application intended.
 2. Strength: As necessary for supporting sealing compound during application.
 3. Resiliency: Sufficient resiliency to prevent significant load transfer across joint.
 4. Resistance to environmental conditions of installation.
 5. Bonding: No bonding to the sealing compound.

6. Structure: Cellular, prevents wicking or absorption of water.
7. Compatibility with other materials in joint and acceptance by manufacturer of sealing compound.
8. Size: Minimum 25 percent greater than nominal joint width.

2.06 RELATED MATERIALS

- A. Primer: Nonstaining type, recommended by sealant manufacturer to suit application.
- B. Joint cleaner: Noncorrosive, nonstaining, compatible with joint forming materials and as recommended by sealant manufacturer.
- C. Bond breaker tape: Pressure-sensitive tape recommended by sealant manufacturer to suit application.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify acceptability of joint dimensions, physical, and environmental conditions.
- B. Verify that surfaces are dry, clean, and free of dirt, grease, curing compound, and other residue which might interfere with adhesion of sealants.

3.02 PREPARATION

- A. Allow concrete to cure thoroughly before caulking.
- B. Synthetic sponge rubber filler:
 1. Prepare surfaces designated to receive filler in accordance with manufacturer's installation instructions.
 2. Do not stretch filler beyond its normal length during installation.
- C. Caulking:
 1. Verify that surfaces are dry, clean, and free of dirt, grease, curing compounds, and other residue that might interfere with adhesion of caulking compound.
 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 is dry and free of dust, dirt, and other foreign residue.
 2. Heavy sandblasted caulking groove to sound surface, and prime with manufacturer's recommended primer for particular surface.
- E. For sidewalks, pavements, and similar joints sealed with elastomeric sealants and subject to traffic and other abrasion and indentation exposures, fill joints to depth equal to 75 percent of joint width, but neither more than 5/8-inches deep nor less than 3/8-inches deep.

- F. For normal moving building joints sealed with elastomeric sealants not subject to traffic, fill joints to depth equal to 50 percent of joint width, but neither more than 1/2-inch deep nor less than 1/4-inch deep.
- G. For joints sealed with acrylic-latex sealants, fill joints to depth in range of 75 percent to 125 percent of joint width.
- H. Use joint filler to achieve required joint depths, to allow sealants to perform properly.
- I. Prepare surfaces and install synthetic sponge rubber filler in accordance with manufacturer's recommendations.
- J. Do not stretch filler beyond normal length during installation.
- K. Apply bond breaker when recommended by joint sealer manufacturer.

3.03 INSTALLATION

- A. Synthetic sponge rubber filler: Install filler in accordance with manufacturer's installation instructions.
- B. Caulking, joints, and sealing:
 - 1. Construct expansion, contraction, and construction joints as indicated on the Drawings.
 - 2. Install pipe and conduit in structures as indicated on the Drawings.
 - 3. Caulk doors, windows, louvers, and other items installed in or over concrete openings inside and out.
 - 4. Use synthetic rubber sealing compound for caulking where indicated on the Drawings or as specified, except for masonry construction and where specified otherwise.
 - 5. Complete caulking prior to painting.
 - 6. Verify that concrete is thoroughly cured prior to caulking.
 - 7. When filler compressible material is used, use untreated type.
 - 8. Apply caulking with pneumatic caulking gun.
 - 9. Use nozzles of proper shape and size for application intended.
 - 10. Maintain continuous bond between caulking and sides of joint to eliminate gaps, bubbles, or voids and fill joint in continuous operation without layering of compound.
 - 11. Employ experienced applicators to caulk joints and seams in neat workmanlike manner.
 - 12. To hasten curing of compound when used on wide joints subject to movement, apply heat with infrared lamps or other convenient means.
 - 13. Apply synthetic rubber sealing compound with pneumatic caulking tool or other acceptable method.

3.04 CLEANING

- A. Clean surfaces adjacent to sealant as work progresses.

- B. Remove excess uncured sealant by soaking and scrubbing with sealant cleaning solvent.
- C. Remove excess cured sealant by sanding with Number 80 grit sandpaper.
- D. Leave finished work in neat, clean condition.

3.05 SCHEDULE

- A. Synthetic rubber sealing compound, non-sag Type II:
 - 1. Use where indicated on the Drawings.
 - 2. Water-bearing and earth-bearing concrete structures.
 - 3. Joints in masonry, concrete vertical surfaces, and metal-faced panels in vertical surfaces.
 - 4. Joints between sheet metal flashing and trim.
 - 5. Joints between sheet metal flashing and trim, and vertical wall surfaces.
 - 6. Small voids between materials requiring filling for weathertight performance in vertical surfaces.
 - 7. Perimeters of frames of doors, windows, louvers, and other openings where bonding is critical to airtight performance.
 - 8. Expansion and control joints in masonry vertical surfaces.
- B. 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.
- C. 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.
- D. 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.

END OF SECTION

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SECTION 09960A

HIGH-PERFORMANCE COATINGS: VOC LIMIT 250 GRAMS PER LITER

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Field applied coatings.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the CONTRACTOR'S responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR'S Work.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
 - a. Division 1 - General Conditions.
 - b. Section 15075 - Equipment Identification.
 - c. Division 16 - Electrical.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. D 16 - Standard Terminology for Paint, Related Coatings, Materials, and Applications.
 - 2. D 4541 - Standard Test Method for Pull-off Strength of Coatings Using Portable Adhesion Testers.
- B. NACE International (NACE):
 - 1. SP0178 - Design, Fabrication, and Surface Finish Practices for Tanks and Vessels to Be Lined for Immersion Service.
 - 2. SP0188-06 - Discontinuity (Holiday) Testing of Protective Coatings.
- C. National Association of Pipe Fabricators (NAPF):
 - 1. 500-03 - Surface Preparation Standard for Ductile Iron Pipe and Fittings Receiving Special External Coatings and/or Special Internal Linings.
- D. NSF International (NSF):
 - 1. 61 - Drinking Water System Components - Health Effects.
- E. Society for Protective Coatings (SSPC):
 - 1. SP COM - Surface Preparation Commentary for Steel and Concrete Substrates.

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2. SP-1 - Solvent Cleaning.
3. SP-2 - Hand Tool Cleaning.
4. SP-3 - Power Tool Cleaning.
5. SP-5 - White Metal Blast Cleaning.
6. SP-6 - Commercial Blast Cleaning.
7. SP-7 - Brush-Off Blast Cleaning.
8. SP-10 - Near-White Blast Cleaning.

F. U.S. Environment Protection Agency (EPA):

1. Method 24 - Surface Coatings.

1.03 DEFINITIONS

- A. Submerged metal: Steel or iron surfaces below tops of channel or structure walls which will contain water even when above expected water level.
- B. Submerged concrete and masonry surfaces: Surfaces which are or will be:
 1. Underwater.
 2. In structures which normally contain water.
 3. Below tops of walls of water containing structures.
- C. Exposed surface: Any metal or concrete surface, indoors or outdoors that is exposed to view.
- D. Dry film thickness (DFT): Thickness of fully cured coating, measured in mils.
- E. Volatile organic compound (VOC): Content of air polluting hydrocarbons in uncured coating product measured in units of grams per liter or pounds per gallon, as determined by EPA Method 24.
- F. Ferrous: Cast iron, ductile iron, wrought iron, and all steel alloys except stainless steel.
- G. Where SSPC surface preparation standards are specified or implied for ductile iron pipe or fittings, the equivalent NAPF surface preparation standard shall be substituted for the SSPC standard.

1.04 PERFORMANCE REQUIREMENTS

- A. Coating materials shall be especially adapted for use in water treat pump stations.
- B. Coating materials used in contact with potable water supply systems shall be certified to NSF 61.

1.05 SUBMITTALS

- A. General: Submit in accordance with Division 1 General Conditions.
- B. Shop drawings:
 1. Schedule of proposed coating materials.
 2. Schedule of surfaces to be coated with each coating material.

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- C. Product Data: Include description of physical properties of coatings including solids content and ingredient analysis, VOC content, temperature resistance, typical exposures and limitations, and manufacturer's standard color chips:
 - 1. Regulatory requirements: Submit data concerning the following:
 - a. Volatile organic compound limitations.
 - b. Coatings containing lead compounds and PCBs.
 - c. Abrasives and abrasive blast cleaning techniques, and disposal.
 - d. NSF certification of coatings for use in potable water supply systems.
- D. Samples: Include 8-inch square drawdowns or brush-outs of topcoat finish when requested. Identify each sample as to finish, formula, color name and number and sheen name and gloss units.
- E. Certificates: Submit in accordance with requirements for Product Data.
- F. Manufacturer's Instructions: Include the following:
 - 1. Special requirements for transportation and storage.
 - 2. Mixing instructions.
 - 3. Shelf life.
 - 4. Pot life of material.
 - 5. Precautions for applications free of defects.
 - 6. Surface preparation.
 - 7. Method of application.
 - 8. Recommended number of coats.
 - 9. Recommended dry film thickness (DFT) of each coat.
 - 10. Recommended total dry film thickness (DFT).
 - 11. Drying time of each coat, including prime coat.
 - 12. Required prime coat.
 - 13. Compatible and non-compatible prime coats.
 - 14. Recommended thinners, when recommended.
 - 15. Limits of ambient conditions during and after application.
 - 16. Time allowed between coats (minimum and maximum).
 - 17. Required protection from sun, wind, and other conditions.
 - 18. Touch-up requirements and limitations.
 - 19. Minimum adhesion of each system submitted in accordance with ASTM D 4541.
- G. Manufacturer's Representative's Field Reports.
- H. Operations and Maintenance Data: Submit as specified in Division 1 General Conditions.
 - 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 items that are "shop coated."
- I. Quality Assurance Submittals:
 - 1. Quality Assurance plan.

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2. Qualifications of coating applicator including List of Similar Projects.

J. California certifications:

1. Submit notarized certificate that:

- a. All paints and coatings to be used on this project comply with the State of California Air Resources Board Rule 1113 VOC Regulations effective as of January 1, 2004; and that
- b. All paints and coatings to be used on this project comply with the VOC regulations of the State of California Air Management District in which the coatings will be used, effective January 1, 2004.

1.06 QUALITY ASSURANCE

A. Applicator qualifications:

1. Minimum of 5 years' 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 2 years.
2. Manufacturer approved applicator when manufacturer has approved applicator program.

B. Regulatory requirements: Comply with governing agencies regulations by using coatings that do not exceed permissible volatile organic compound limits and do not contain lead:

1. Do not use coal tar epoxy in contact with drinking water or exposed to ultraviolet radiation.

C. Field samples: Prepare and coat a minimum 10 square foot area between corners or limits such as control or construction joints of each system. Approved field sample may be part of Work.

D. Pre-installation conference: Conduct as specified in Division 1 General Conditions.

E. Compatibility of coatings: Use products by same manufacturer for prime coats, intermediate coats, and finish coats on same surface, unless specified otherwise.

F. Services of coating manufacturer's representative: Arrange for coating manufacturer's representative to attend pre-installation conferences. Make periodic visits to the project site to provide consultation and inspection services during surface preparation and application of coatings, and to make visits to coating plants to observe and approve surface preparation procedures and coating application of items to be "shop primed and coated."

1.07 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle products as specified in Division 1 General Conditions.

B. Remove unspecified and unapproved paints from Project site immediately.

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- C. Deliver new unopened containers with labels identifying the manufacturer's name, brand name, product type, batch number, date of manufacturer, expiration date or shelf life, color, and mixing and reducing instructions.
 - 1. Do not deliver materials aged more than 12 months from manufacturing date.
- D. Store coatings in well-ventilated facility that provides protection from the sun weather, and fire hazards. Maintain ambient storage temperature between 45 and 90 degrees Fahrenheit, unless otherwise recommended by the manufacturer.
- E. Take precautions to prevent fire and spontaneous combustion.

1.08 PROJECT CONDITIONS

- A. Surface moisture contents: Do not coat surfaces that exceed manufacturer specified moisture contents, or when not specified by the manufacturer, the following moisture contents:
 - 1. Plaster and gypsum wallboard: 12 percent.
 - 2. Masonry, concrete, and concrete block: 12 percent.
 - 3. Interior located wood: 15 percent.
 - 4. Concrete floors: 7 percent.
- B. Do not apply coatings:
 - 1. Under dusty conditions or adverse environmental conditions, unless tenting, covers, or other such protection is provided for structures to be coated.
 - 2. When light on surfaces measures less than 15 foot-candles.
 - 3. When ambient or surface temperature is less than 55 degrees Fahrenheit unless manufacturer allows a lower temperature.
 - 4. When relative humidity is higher than 85 percent.
 - 5. When surface temperature is less than 5 degrees Fahrenheit above dew point.
 - 6. When surface temperature exceeds the manufacturer's recommendation.
 - 7. When ambient temperature exceeds 90 degrees Fahrenheit, unless manufacturer allows a higher temperature.
 - 8. Apply clear finishes at minimum 65 degrees Fahrenheit.
- C. Provide fans, heating devices, dehumidifiers, or other means recommended by coating manufacturer to prevent formation of condensate or dew on surface of substrate, coating between coats and within curing time following application of last coat.
- D. Provide adequate continuous ventilation and sufficient heating facilities to maintain minimum 55 degrees Fahrenheit for 24 hours before, during and 48 hours after application of finishes.

1.09 SEQUENCING AND SCHEDULING

- A. Sequence and Schedule: As specified in Division 1 General Conditions.

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1.10 MAINTENANCE

- A. Extra materials: Deliver as specified in Division 1 General Conditions. Include minimum 1 gallon of each type and color of coating applied:
 - 1. When manufacturer packages material in gallon cans, deliver unopened labeled cans as comes from factory.
 - 2. When manufacturer does not package material in gallon cans, deliver material in new gallon containers, properly sealed and identified with typed labels indicating brand, type, and color.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Special coatings: One of the following or equal:
 - 1. Carboline: Carboline, St. Louis, MO.
 - 2. Ceilcote: Ceilcote Corrosion Control, Berea, OH.
 - 3. Dampney: The Dampney Company, Everett, MA.
 - 4. Devoe: ICI Devoe Coatings, Louisville, KY.
 - 5. Dudick: Dudick, Inc., Streetsboro, OH.
 - 6. GET: Global Eco Technologies, Pittsburg, CA.
 - 7. Henkel: Henkel North America, Madison Heights MI.
 - 8. IET: Integrated Environmental Technologies, Santa Barbara, CA.
 - 9. PPG Amercoat: PPG Protective & Marine Coatings, Brea, CA.
 - 10. Sanchem: Sanchem, Chicago, IL.
 - 11. Superior: Superior Environmental Products, Inc., Addison, TX.
 - 12. S-W: Sherwin-Williams Co., Cleveland, OH.
 - 13. Tnemec: Tnemec Co., Kansas City, MO.
 - 14. Wasser: Wasser High Tech Coatings, Kent, WA.

2.02 PREPARATION AND PRETREATMENT MATERIALS

- A. Metal pretreatment: As manufactured by one of the following or equal:
 - 1. Henkel: Galvaprep 5.
 - 2. International: AWLGrip Alumiprep 33.
 - 3. S-W: Macropoxy 646 Fast Cure.
 - 4. Tnemec: Series N69 Hi-Build Epoxoline.
- B. Surface cleaner and degreaser: As manufactured by one of the following or equal:
 - 1. Carboline Surface Cleaner No.3.
 - 2. Devoe: Devprep 88.
 - 3. S-W: Clean and Etch.

2.03 COATING MATERIALS

- A. High solids epoxy (self-priming) not less than 72 percent solids by volume: As manufactured by one of the following or equal:
 - 1. Carboline: Carboguard 891.
 - 2. Devoe: Bar Rust 233H.

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3. PPG Amercoat: Amerlock 2.
 4. S-W: Macropoxy 646.
- B. Aliphatic or aliphatic-acrylic polyurethane: As manufactured by one of the following or equal:
1. Carboline: Carbothane 134 VOC.
 2. Devoe: Devthane 379.
 3. PPG Amercoat: Amershield VOC.
 4. S-W: High Solids Polyurethane CA.
 5. Tnemec: Endura-Shield II Series 1075 (U).
- C. High temperature coating 150 to 350 degrees Fahrenheit: As manufactured by one of the following or equal:
1. Carboline: Thermaline 4900.
 2. Dampney: Thermalox 245 Silicone - Zinc Dust.
 3. PPG Amercoat: Amerlock 2/400 GFK.
- D. High temperature coating 400 to 1,000 degrees Fahrenheit (dry): As manufactured by one of the following or equal:
1. Carboline: Thermaline 4700.
 2. Dampney: Thermolox 230C Series Silicone.
 3. Devoe: HT-12, High Heat Silicone.
- E. High temperature coating up to 1,400 degrees Fahrenheit: As manufactured by the following or equal:
1. Dampney: Thermalox 240 Silicone Ceramix.
- F. Asphalt varnish: AWWA C 500.
- G. Vinyl ester: Glass mat reinforced, total system 125 mils DFT. As manufactured by one of the following or equal:
1. Carboline: Semstone 870.
 2. Dudick: Protecto-Flex 800.
- H. Waterborne acrylic emulsion: As manufactured by one of the following or equal:
1. S-W: DTM Acrylic B66W1.
 2. Tnemec: Tneme-Cryl Series 6.

2.04 MIXES

- A. Mix epoxy parts in accordance with manufacturer's instructions.

PART 3 EXECUTION

3.01 GENERAL PROTECTION

- A. Protect adjacent surfaces from coatings and damage. Repair damage resulting from inadequate or unsuitable protection:

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- B. Protect adjacent surfaces not to be coated from spatter and droppings with drop cloths and other coverings:
 - 1. Mask off surfaces of items not to be coated or remove items from area.
- C. Furnish 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 area.
- D. Place cotton waste, cloths, and material which may constitute fire hazard in closed metal containers and remove daily from site.
- E. Remove electrical plates, surface hardware, fittings, and fastenings, prior to application of coating operations. Carefully store, clean, and replace on completion of coating in each area. Do not use solvent or degreasers to clean hardware that may remove permanent lacquer finish.

3.02 GENERAL PREPARATION

- A. Prepare surfaces in accordance with coating manufacturer's instructions, unless more stringent requirements are specified in this Section.
- B. Protect following surfaces from abrasive blasting by masking, or 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 on which sprockets are to fit.
 - 5. Surfaces of shafting on which bearings are to fit.
 - 6. Machined surfaces of bronze trim, including those slide gates.
 - 7. Cadmium-plated items except cadmium-plated, zinc-plated, or sherardized fasteners used in assembly of equipment requiring abrasive blasting.
 - 8. Galvanized items, unless scheduled to be coated.
- C. Protect installed equipment, mechanical drives, and adjacent coated equipment from abrasive blasting to prevent damage caused by entering sand or dust.
- D. Concrete:
 - 1. Allow new concrete to cure for minimum of 28 days before coating.
 - 2. Clean concrete surfaces of dust, mortar, fins, loose concrete particles, form release materials, oil, and grease. Fill voids so that surface is smooth. Etch or brush off-blast clean in accordance with SSPC SP-7 to provide surface profile equal to 40 to 60-grit sandpaper, or as recommended by coating manufacturer. All concrete surfaces shall be vacuumed clean prior to coating application.
- E. Ferrous metal surfaces:
 - 1. Remove grease and oil in accordance with SSPC SP-1.
 - 2. Remove rust, scale, and welding slag and spatter, and prepare surfaces in accordance with appropriate SSPC standard as specified.
 - 3. Abrasive blast surfaces prior to coating.

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4. When abrasive blasted surfaces rust or discolor before coating, abrasive blast surfaces again to remove rust and discoloration.
 5. When metal surfaces are exposed because of coating damage, abrasive blast surfaces and feather in to a smooth transition before touching-up.
 6. All abrasive blast cleaned surfaces shall be blown down with clean dry air and or vacuumed.
- F. Ferrous metal surfaces not to be submerged: Abrasive blast in accordance with SSPC SP-10, unless blasting may damage adjacent surfaces, prohibited or specified otherwise. Where not possible to abrasive blast, power tool clean surfaces in accordance with SSPC SP-3.
- G. Ferrous metal surfaces to be submerged: Unless specified otherwise, abrasive blast in accordance with SSPC SP-5 to clean and provide roughened surface profile of not less than 2 mils and not more than 4 mils in depth when measured with Elcometer 123, or as recommended by the coating manufacturer.
- H. Ductile iron pipe and fittings to be lined or coated: Abrasive blast clean in accordance with NAPF 500-03.
- I. Sherardized, aluminum, copper, and bronze surfaces: Prepare in accordance with coating manufacturer's instructions.
- J. Galvanized surface:
1. Degrease or solvent clean (SSPC SP-1) to remove oily residue.
 2. Power tool or hand tool clean or whip abrasive blast.
 3. Test surface for contaminants using copper sulfate solution.
 4. Apply metal pretreatment within 24 hours before coating galvanized surfaces that cannot be thoroughly abraded physically, such as bolts, nuts, or preformed channels.
- K. Shop primed metal:
1. Certify that primers applied to metal surfaces in the shop are compatible with coatings to be applied over such primers in the field.
 2. Remove shop primer from metal to be submerged by abrasive blasting in accordance with SSPC SP-10, unless greater degree of surface preparation is required by coating manufacturer's representative.
 3. Correct abraded, scratched, or otherwise damaged areas of prime coat by sanding or abrasive blasting to bare metal in accordance with SSPC SP-2, SP 3, or SP-6, as directed by the ENGINEER.
 4. When entire shop priming fails or has weathered excessively (more than 25 percent of the item), or when recommended by coating manufacturer's representative, abrasive blast shop prime coat to remove entire coat and prepare surface in accordance with SSPC SP-10.
 5. When incorrect prime coat is applied, remove incorrect prime coat by abrasive blasting in accordance with SSPC SP-10.
 6. When prime coat not authorized by ENGINEER is applied, remove unauthorized prime coat by abrasive blasting in accordance with SSPC SP-10.

7. Shop applied bituminous paint or asphalt varnish: Abrasive blast clean shop applied bituminous paint or asphalt varnish from surfaces scheduled to receive non-bituminous coatings.
- L. Abrasive blast cadmium-plated, zinc-plated, or sherardized fasteners in same manner as unprotected metal when used in assembly of equipment designated for abrasive blasting.
- M. Abrasive blast components to be attached to surfaces which cannot be abrasive blasted before components are attached.
- N. Grind sharp edges to approximately 1/16-inch radius before abrasive blast cleaning.
- O. Remove and grind smooth all excessive weld material and weld spatter before blast cleaning in accordance with NACE SP0178.
- P. PVC and FRP Surfaces:
 1. Prepare surfaces to be coated by light sanding (de-gloss) and wipe-down with clean cloths, or by solvent cleaning in strict accordance with coating manufacturer's instructions.
- Q. Cleaning of previously coated surfaces:
 1. Utilize cleaning agent to remove soluble salts such as chlorides and sulfates from concrete and metal surfaces:
 - a. Cleaning agent: Biodegradable non-flammable and containing no volatile organic compounds.
 - b. Manufacturer: The following or equal:
 - 1) Chlor-Rid International, Inc.
 2. Steam clean and degrease surfaces to be coated to remove oils and grease.
 3. Cleaning of surfaces utilizing the decontamination cleaning agent may be accomplished in conjunction with abrasive blast cleaning, steam cleaning, high-pressure washing, or hand washing as approved by the coating manufacturer's representative and the ENGINEER.
 4. Test cleaned surfaces in accordance with the cleaning agent manufacturer's instructions to ensure all soluble salts have been removed. Additional cleaning shall be carried out as necessary.
 5. Final surface preparation prior to application of new coating system shall be made in strict accordance with coating manufacturer's printed instructions.

3.03 MECHANICAL AND ELECTRICAL EQUIPMENT PREPARATION

- A. Identify equipment, ducting, piping, and conduit as specified in Section 15075 Equipment Identification and Division 16 Electrical.
- B. Remove grilles, covers, and access panels for mechanical and electrical system from location and coat separately.
- C. Prepare and finish coat-primed equipment with color selected by the ENGINEER.

- D. Prepare and prime and coat insulated and bare pipes, conduits, boxes, insulated and bare ducts, hangers, brackets, collars, and supports, except where items are covered with 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, convector and baseboard heating cabinets that are 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, convector and baseboard cabinets to match face panels.
- H. Prepare and coat exposed conduit and electrical equipment occurring in finished areas with color and texture to match adjacent surfaces.
- I. Prepare and coat both sides 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 Contract Documents.

3.04 GENERAL APPLICATION REQUIREMENTS

- A. Apply coatings in accordance with manufacturer's instructions.
- B. Coat metal unless specified otherwise:
 - 1. Aboveground piping to be coated shall be empty of contents during application of coatings.
- C. Verify metal surface preparation immediately before applying coating in accordance with SSPC SP COM.
- D. Allow surfaces to dry, except where coating manufacturer requires surface wetting before coating.
- E. Wash coat and prime sherardized, aluminum, copper, and bronze surfaces, or prime with manufacturer's recommended special primer.
- F. Prime shop primed metal surfaces. Spot prime exposed metal of shop primed surfaces before applying primer over entire surface.
- G. Apply minimum number of specified coats.
- H. Apply coats to thicknesses specified, especially at edges and corners.
- I. Apply additional coats when necessary to achieve specified thicknesses.

- J. Coat surfaces without drops, overspray, dry spray, runs, ridges, waves, holidays, laps, or brush marks.
- K. Remove spatter and droppings after completion of coating.
- L. When multiple coats of same material are specified, tint prime coat and intermediate coats with suitable pigment to distinguish each coat.
- M. Dust coatings between coats. Lightly sand and dust surfaces to receive high gloss finishes, unless instructed otherwise by coating manufacturer.
- N. Apply coating by brush, roller, trowel, or spray, unless particular method of application is required by coating manufacturer's instructions or these Specifications.
- O. Plural component application: Drums shall be premixed each day. All gauges shall be working order prior to the start of application. Ratio checks shall be completed prior to each application. A spray sample shall be sprayed on plastic sheeting to insure set time is complete prior to each application. Hardness testing shall be performed after each application.
- P. Spray application:
 - 1. Stripe coat edges, welds, nuts, bolts, difficult to reach areas by brush before beginning spray application, as necessary, to ensure specified coating thickness along edges.
 - 2. When using spray application, apply coating to thickness not greater than that recommended in coating manufacturer's instructions for spray application.
 - 3. Use airless spray method, unless air spray method is required by coating manufacturer's instruction or these Specifications.
 - 4. Conduct spray coating under controlled conditions. Protect adjacent construction and property from coating mist, fumes, or overspray.
- Q. Drying and recoating:
 - 1. Provide fans, heating devices, or other means recommended by coating manufacturer to prevent formation of condensate or dew on surface of substrate, coating between coats and within curing time following application of last coat.
 - 2. Limit drying time to that required by these Specifications or coating manufacturer's instructions.
 - 3. Do not allow excessive drying time or exposure which may impair bond between coats.
 - 4. Recoat epoxies within time limits recommended by coating manufacturer.
 - 5. When time limits are exceeded, abrasive blast clean and de-gloss clean prior to applying another coat.
 - 6. When limitation on time between abrasive blasting and coating cannot be met before attachment of components to surfaces which cannot be abrasive blasted, coat components before attachment.
 - 7. Ensure primer and intermediate coats of coating are unscarred and completely integral at time of application of each succeeding coat.
 - 8. Touch up suction spots between coats and apply additional coats where required to produce finished surface of solid, even color, free of defects.

9. Leave no holidays.
10. Sand and feather in to a smooth transition and recoat and recoat scratched, contaminated, or otherwise damaged coating surfaces so damages are invisible to naked eye.

R. Concrete:

1. Apply first coat (primer) only when surface temperature of concrete is decreasing in order to eliminate effects of off-gassing on coating.

3.05 HIGH SOLIDS EPOXY SYSTEM

A. Preparation:

1. Prepare surfaces in accordance with general preparation requirements and as follows:
 - a. Abrasive blast ferrous metal surfaces to be submerged at jobsite in accordance with SSPC SP-5 prior to coating. When cleaned surfaces rust or discolor, abrasive blast surfaces in accordance with SSPC SP-10.
 - b. Abrasive blast non-submerged ferrous metal surfaces at jobsite in accordance with SSPC SP-10, prior to coating. When cleaned surfaces rust or discolor, abrasive blast surfaces in accordance with SSPC SP 6.
 - c. Abrasive blast clean ductile iron surfaces at jobsite in accordance with SSPC SP-7.

B. Application:

1. Apply coatings in accordance with general application requirements and as follows:
 - a. Apply minimum 2-coat system with minimum total dry film thickness (DFT) of 12 mils.
 - b. Recoat or apply succeeding epoxy coats within time limits recommended by manufacturer. Prepare surfaces for recoating in accordance with manufacturer's instructions.
 - c. Coat metal to be submerged before installation when necessary, to obtain acceptable finish and to prevent damage to other surfaces.
 - d. Coat entire surface of support brackets, stem guides, pipe clips, fasteners, and other metal devices bolted to concrete.
 - e. Coat surface of items to be exposed and adjacent 1 inch to be concealed when embedded in concrete or masonry.

3.06 HIGH SOLIDS EPOXY AND POLYURETHANE COATING SYSTEM

A. Preparation:

1. Prepare surfaces in accordance with general preparation requirements and as follows:
 - a. Prepare concrete surfaces in accordance with general preparation requirements.
 - b. Touch up shop primed steel and miscellaneous iron.
 - c. Abrasive blast ferrous metal surfaces at jobsite in accordance with SSPC SP 6, prior to coating. When cleaned surfaces rust or discolor, abrasive blast surfaces in accordance with SSPC SP 6.

- d. Degrease or solvent clean, whip abrasive blast, power tool, or hand tool clean galvanized metal surfaces.
- e. Lightly sand (de-gloss) fiberglass and poly vinyl chloride (PVC) pipe to be coated and wipe clean with dry cloths, or solvent clean in accordance with coating manufacturer's instructions.
- f. Abrasive blast clean ductile iron surfaces.

B. Application:

- 1. Apply coatings in accordance with general application requirements and as follows:
 - a. Apply 3 coat system consisting of:
 - 1) Primer: 4 to 5 mils dry film thickness high solids epoxy.
 - 2) Intermediate coat: 4 to 5 mils dry film thickness high solids epoxy.
 - 3) Topcoat: 2.5 to 3.5 mils dry film thickness aliphatic or aliphatic-acrylic polyurethane topcoat.
- 2. Recoat or apply succeeding epoxy coats within 30 days or within time limits recommended by manufacturer, whichever is shorter. Prepare surfaces for recoating in accordance with manufacturer's instructions.

3.07 HIGH TEMPERATURE COATING

A. Preparation:

- 1. Prepare surfaces in accordance with general preparation requirements and as follows:
 - a. Abrasive blast surface in accordance with SSPC SP-10.

B. Application:

- 1. Apply coatings in accordance with general application requirements and as follows:
 - a. Apply number of coats in accordance with manufacturer's instructions.

3.08 VINYL ESTER

A. Preparation:

- 1. Prepare surfaces in accordance with coating manufacturer's recommendations and as directed and approved by coating manufacturer's representative.

B. Application:

- 1. Apply prime coat, as required by coating manufacturer, base coat, glass mat, and topcoat to total dry film thickness of 125 mils minimum:
 - a. Final topcoat on floors shall include non-skid surface, applied in accordance with manufacturer's instructions.
- 2. Perform high voltage holiday detection test in accordance with SP0188-06, over 100 percent of coated surface areas to ensure pinhole free finished coating system.
- 3. All work shall be accomplished in strict accordance with coating manufacturer's instructions and under direction of coating manufacturer's representative.

3.09 WATERBORNE ACRYLIC EMULSION

A. Preparation:

1. Remove all oil, grease, dirt, and other foreign material by Solvent Cleaning in accordance with SSPC SP-1.
2. Lightly sand all surfaces and wipe thoroughly with clean cotton cloths before applying coating.

B. Application:

1. Apply 2 or more coats to obtain a minimum dry film thickness (DFT) of 5.0 mils.

3.10 FIELD QUALITY CONTROL

- A. Each coat will be inspected. Strip and remove defective coats, prepare surfaces and recoat. When approved, apply next coat.
- B. Control and check dry film thicknesses and integrity of coatings.
- C. Measure dry film thickness with calibrated thickness gauge.
- D. Dry film thicknesses on ferrous-based substrates may be checked with Elcometer Type 1 Magnetic Pull-Off Gage or Positector 6000.
- E. Verify coat integrity with low-voltage holiday detector, in accordance with SP0188 06. Allow ENGINEER to use detector for additional checking.
- F. Check wet film thickness before coal tar epoxy coating cures on concrete or non-ferrous metal substrates.
- G. Arrange for services of coating manufacturer's field representative to provide periodic field consultation and inspection services to ensure proper surface preparation of facilities and items to be coated, and to ensure proper application and curing:
 1. Notify ENGINEER 24 hours in advance of each visit by coating manufacturer's representative.
 2. Provide ENGINEER with a written report by coating manufacturer's representative within 48 hours following each visit.

3.11 SCHEDULE OF ITEMS NOT REQUIRING COATING

- A. General: Unless specified otherwise, the following items do not require coating:
 1. Items that have received final coat at factory and not listed to receive coating in field.
 2. Aluminum, brass, bronze, copper, plastic (except PVC pipe), rubber, stainless steel, chrome, Everdur, or lead.
 3. Buried or encased piping or conduit.
 4. Exterior concrete.
 5. Galvanized steel wall framing, galvanized electrical conduits, galvanized pipe trays, galvanized cable trays, and other galvanized items:

- a. Areas on galvanized items or parts where galvanizing has been damaged during handling or construction shall be repaired as follows:
 - 1) Clean damaged areas by SSPC SP-1, SP-2, SP-3, or SP-7 as required.
 - 2) Apply 2 coats of a cold galvanizing zinc compound such as ZRC World Wide Inovatie Zinc Technologies of Mansfield, MA or accepted equal, in strict accordance with manufacturer's instructions.
- 6. Grease fittings.
- 7. Fiberglass ducting or tanks in concealed locations.
- 8. Steel to be encased in concrete or masonry.

3.12 SCHEDULE OF SURFACES TO BE COATED IN THE FIELD

- A. In general, apply coatings to steel, iron, galvanized surfaces, and wood surfaces unless specified or otherwise indicated on the Drawings. Coat concrete surfaces and anodized aluminum only when specified or indicated on the Drawings. Color coat all piping as specified in Section 15075 Equipment Identification.
- B. Following schedule is incomplete. Coat unlisted surfaces with same coating system as similar listed surfaces. Verify questionable surfaces.
- C. Concrete:
 - 1. High solids epoxy:
 - a. Safety markings.
 - 2. Vinyl ester:
 - a. Secondary containment: All concrete surfaces inside chemical containment areas including inside wall surfaces, top of wall surfaces, sump area, tank fill area, including equipment pads, and tank pads. See Drawings for area to be coated in Hypochlorite Room.
 - b. Suitable for 72 hours submerged in:
 - 1) 12 percent to 15 percent sodium hypochlorite.
 - c. Concrete floor surfaces in chemical containment areas shall have a non-skid surface.
- D. Metals:
 - 1. High solids epoxy and polyurethane system: Interior and exterior non-immersed ferrous metal surfaces including:
 - 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 including galvanized structural steel.
 - 1) Exposed metal decking.
 - g. Crane and hoist rails.

- h. Mechanical equipment supports, drive units, and accessories.
 - i. Pumps not submerged.
 - j. Other miscellaneous metals.
 - 2. High solids epoxy system:
 - a. Field priming of ferrous metal surfaces with defective shop prime coat where no other prime coat is specified; for non-submerged service.
 - b. Bell rings, underside of manhole covers and frames.
 - c. Sump pumps, including underside of base plates and submerged suction and discharge piping.
 - d. Stem guides.
 - e. Other submerged iron and steel metal unless specified otherwise.
 - f. Interior surface of suction inlet and volute of submersible influent pumps. Apply coating prior to pump testing.
 - 3. High temperature coating 400 to 1,000 degrees Fahrenheit:
 - a. Generator Exhaust.
- E. Fiberglass and PVC pipe surfaces:
 - 1. Waterborne acrylic emulsion.
 - 2. Exterior of fiberglass ducting and fan housings.
 - 3. Fiberglass expose to sunlight.
 - 4. PVC piping exposed to view.
 - 5. ABS piping as determined by ENGINEER.

END OF SECTION

SECTION 10400

SIGNAGE

PART 1 GENERAL

1.01 SUMMARY

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

1.02 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.

1.03 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 PLASTIC SIGNAGE SYSTEM

- A. Manufacturers:
 - 1. One of the following or equal:
 - a. Best Manufacturing Sign Systems, Montrose, CO; System 900013.
 - b. Andco Industries Corp., Greensboro, NC; equivalent product.
 - c. Vomar Products, Inc., Sepulveda, CA; equivalent product.
- B. Attachment:
 - 1. Vinyl tape, self-adhering.

- C. Lettering:
 - 1. Helvetica medium, 3/4 inches high.
- D. Material for interior use:
 - 1. Plastic 1/8-inch thick raised letters.
- E. Material for exterior use:
 - 1. Fiberglass 1/4-inch thick with high gloss finish, raised letters, blasted from single piece of fiberglass for integral letter and background.
 - 2. No adhesive as mechanical fastening of letters shall be allowed.
- F. Colors:
 - 1. As selected by ENGINEER from manufacturer's standard colors.
- G. See Schedule A for specific sign size, location, text, pictogram, and quantity.

2.02 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., Branford, Connecticut, Special Wording.
 - 2. Emedco, Buffalo, New York.
- B. Danger sign colors:
 - 1. Background: White.
 - 2. Heading: White lettering on red oval with white border in black rectangular panel.
 - 3. Message: Black lettering on white.
 - 4. Size: As scheduled.
- C. Caution sign colors:
 - 1. Background: Yellow.
 - 2. Heading: Yellow lettering on black rectangular panel.
 - 3. Message: Black lettering on yellow.
 - 4. Size: As scheduled.
- D. Safety instruction signs:
 - 1. Background: White.
 - 2. Heading: White lettering on green rectangular panel.
 - 3. Message: Black lettering.
 - 4. Size: As scheduled.
- E. Warning sign colors:
 - 1. Background: Orange.
 - 2. Heading: Black lettering on orange diamond in black rectangular panel.
 - 3. Message: Black lettering on orange.
 - 4. Size: As scheduled.
- F. Notice information signs:
 - 1. Background: White.

2. Heading: White lettering on blue rectangular panel.
 3. Message: Black lettering.
 4. Size: As scheduled.
- G. Fasteners: Round head stainless steel bolts or screws.
- H. See Schedule B for specific sign size, location, text, and quantity.

2.03 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, Montrose, CO; equivalent product.
 - b. Andco Industries Corp., Greensboro, NC; equivalent product.
 - c. Vomar Products, Inc., Sepulveda, CA; 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.

2.04 CAST METAL PLAQUE

- A. Manufacturers: One of the following or equal:
1. Andco Industries Corp., Greensboro, NC.
 2. Southwell Co., San Antonio, TX.
 3. ARK-RAMOS Inc., Oklahoma City, OK.
- B. Material: Cast bronze.
- C. Size: Approximately 28 by 34 inches by minimum 3/16 inches thick; lettering, center panel, and trim raised 1/8 inch.
- D. Lettering: Text as indicated on the Drawings directed by ENGINEER. Verify before fabrication.
- E. Finishes:
1. Lettering, center panel, and trim: Fine satin.
 2. Background: Finely pebbled, oxidized to dull black color.
- F. Mounting: Concealed with fasteners.

2.05 HAZARD MATERIAL SIGNALS

- A. Manufacturer: One of the following or equal:
 - 1. Seton Name Plate Co., Branford, Connecticut.
 - 2. Emedco, Buffalo, New York.
- B. Hazard material signals: In accordance with NFPA 704, 2007; vinyl panels, letters, and symbols with pressure sensitive adhesive, sizes as required for viewing distances, letters and symbols in accordance with Schedule C.

2.06 CAST ALUMINUM LETTERS

- A. Manufacturers:
 - 1. One of the following or equal:
 - a. Metal Arts, Mandan, ND.
 - b. Southwell Company, San Antonio, TX.
 - c. OMC Industries, Bryan, TX.
- B. Material:
 - 1. Cast aluminum.
- C. Text size and font:
 - 1. As indicated on the Drawings.
- D. Finish:
 - 1. Black duranodic coating.
- E. Mounting:
 - 1. Projected jamb nut mounting, concealed.

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 or as indicated in the following schedules.

3.03 SCHEDULES

- A. Plastic Signage System Schedule.
- B. Metal Safety Sign Schedule.
- C. Hazard Material Signals.

END OF SECTION

SCHEDULE A

PLASTIC SIGNAGE SYSTEM SCHEDULE

A. Room Names:

1. Location: On wall outside room adjacent to latch side of doors or when not enough space on latch side, on nearest adjacent wall.
2. Height: 60 inches above floor to center of sign.
3. Size: 6 inches square.
4. Colors: As selected by ENGINEER.
5. Text: Sign per door describing room function as indicated on the Drawings.

B. Toilet Doors:

1. Location: On wall outside room adjacent to latch side of doors or when not enough space on latch side, on nearest adjacent wall.
2. Height: 60 inches above floor to center of sign.
3. Size: 6 inches wide by 8 inches high.
4. Colors: As selected by ENGINEER.
5. Pictogram: International symbol for men or women to suit application.
6. Text: Braille Characters and MEN or WOMEN as appropriate.

C. Fire Extinguishers:

1. Location: Adjacent to fire extinguishers.
2. Height: 60 inches above floor to center of sign.
3. Size: 6 inches square.
4. Colors: White letters on OSHA Red background.
5. Text: FIRE EXTINGUISHER.

END OF SCHEDULE A

SCHEDULE B
METAL SAFETY SIGN SCHEDULE

A. CHLORINATION EQUIPMENT:

1. Location: Adjacent to exterior doors and gate of Hypochlorite Room.
2. Height: 5 feet 0 inches.
3. Size: 14 inches wide by 10 inches high.
4. Heading: CAUTION
5. Wording: CHLORINATION EQUIPMENT

B. EMERGENCY EXIT:

1. Location: Exterior side of Chlorination-Dechlorination Building doors.
2. Height: _____.
3. Size: 20 inches wide by 14 inches high
4. Heading: DANGER
5. Wording: BEFORE ENTERING
TURN ON EXTERIOR VENTILATION
AND LIGHT SWITCHES

ALLOW BUILDING TO VENTILATE

C. REMOTELY CONTROLLED AUTOMATIC EQUIPMENT:

1. Location: On front and back of equipment that starts automatically by remote control.
2. Size: 2 feet by 2 feet.
3. Heading: DANGER
4. Wording: THIS EQUIPMENT STARTS AUTOMATICALLY
BY REMOTE CONTROL

D. HIGH VOLTAGE WARNING:

1. Location: On front and back of equipment, adjacent to doors to rooms containing devices, and devices that operate at 600 volts or greater.
2. Height: 5 feet 0 inches.
3. Size: 2 feet by 2 feet.
4. Heading: DANGER
5. Wording: HIGH VOLTAGE

E. NO SMOKING INFORMATIONAL SIGNS:

1. Location: On exterior face of wall, adjacent to each entry point (exterior door) to all buildings.
2. Height: 60 inches above floor to center of sign. Where metal safety signs are also located adjacent to entry points, place no smoking signs below these signs.
3. Size: 6 inches square.
4. Heading: None.
5. Wording: None.

- 6. Pictogram: International "No Smoking" symbol.
- F. NO SMOKING WITHIN 25 FEET OF BUILDING ENTRY:
 - 1. Location: As indicated on the Drawings.
 - 2. Height: Pole mounted with top of sign at 5 feet above grade.
 - 3. Size: 14 inches wide by 10 inches high.
 - 4. Heading: NOTICE
 - 5. Wording: NO SMOKING WITHIN 25 FEET OF BUILDING.
 - 6. Pictogram: International "No Smoking" symbol.

END OF SCHEDULE B

SCHEDULE C
HAZARD MATERIAL SIGNALS

A. HAZARD SIGNAL FOR SODIUM HYPOCHLORITE 12 PERCENT:

1. Location: At entrances to locations where stored and on storage tanks.
2. Height: 5'6"
3. View Distance: 10 feet.
4. Health: 3
5. Flammability: 0
6. Reactivity: 0
7. Special: COR

B. HAZARD SIGNAL FOR DIESEL FUEL:

1. Location: At entrance to generator room or where fuel is stored.
2. Height: 5'6"
3. View Distance: 50 feet.
4. Health: 2
5. Flammability: 2
6. Reactivity: 0
7. Special: -

END OF SCHEDULE C

SECTION 11312J

SUBMERSIBLE SUMP PUMP

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Submersible sump pumps.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the CONTRACTOR'S responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR'S Work.
 - 3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
 - a. Division 1 - General Conditions.
 - b. Section 09960A - High-Performance Coatings: VOC Limit 250 Grams per Liter.
 - c. Section 15050 - Common Work Results for Mechanical Equipment.
 - d. Section 15958 - Mechanical Equipment Testing.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. A 48 - Standard Specification for Gray Iron Castings.
 - 2. A 276 - Standard Specification for Stainless Steel Bars and Shapes.
 - 3. D 2000 - Standard Classification System for Rubber Products in Automotive Applications.
- B. Hydraulic Institute (HI):
 - 1. 1.1-1.2 - 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 (1,000 V Maximum)

1.03 DEFINITIONS

- A. 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.
- B. 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: discharge piping, necessary valves, and other items as required for a complete and operational system.
- B. Design requirements:
 - 1. Pump performance characteristics: As specified in the Pump Schedule.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Pumps: One of the following or equal:
 - 1. Barnes (Crane Pumps & Systems)
 - 2. ITT Goulds Pumps
 - 3. Hydromatic
 - 4. ESSCO

2.02 MATERIALS

- A. Cast Iron: ASTM A 48, Class 30 minimum.
- B. Stainless Steel: ASTM A 276 or equal.
- C. Buna N: ASTM D 2000.

2.03 PUMP CASING

- A. Material: Cast iron.
- B. Provide support legs on sump bottom and clearance for suction entrance.
- C. The discharge connection shall be a 1.5-inch NPT vertical connection.

2.04 IMPELLERS

- A. Material: Cast iron.

B. 2-vane; maximum enclosed; nonclogging; with pump-out vanes on backside; dynamically balanced; close coupled to motors.

C. Method of securing to shafts: Treaded lock nut or similar connection.

2.05 PUMP SHAFTS

A. Material: 400 series stainless steel or approved alternative.

2.06 BEARINGS

A. Upper bearing: Single row; oil lubricated.

B. Lower bearing: Single row; oil lubricated.

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. Motor must be approved by U.L. for a Class 1, Division 2, hazardous location.
2. Air or oil filled submersible motor is acceptable.
3. Insulation:
 - a. Class F rated for continuous duty.
4. Power: 230/460 volt, 3 phase, 60 hertz.
5. Horsepower: No greater than 1 HP.
6. Cable: Electrical cable leads shall be 15 feet in length and joined to motor enclosure by use of an epoxy mold and blind-splice in the motor end bracket. The sealing method shall be approved by U.L. for a class 1, Group C & D, Division 1, hazardous location.

2.09 SIMPLEX CONTROL PANEL

A. The CONTRACTOR shall furnish and install all materials, labor, equipment, and incidentals required to provide a motor control panel for the simplex pump station.

B. Control and operation shall be from float switch, located in the sump. The CONTRACTOR shall provide the wiring of the floats and pumps between the sump and the control panel.

C. The CONTRACTOR shall install the control panel as indicated on the contract drawings. All equipment shall be mounted in a NEMA 4X stainless steel enclosure.

Power shall be 3 wire, 480-volt, 3 phase. Control power shall be 120 volts supplied from a control transformer mounted inside the control panel. The transformer shall be fused on both the primary and secondary sides.

- D. The enclosure shall be a NEMA 4X stainless steel with "deadfront" inner door assembly. The outer door of the enclosure shall be able to accommodate a padlock. The enclosure shall be fabricated of type 304 stainless steel with a white painted steel removable sup-panel.
- E. A three-pole main circuit breaker shall be provided. The circuit breaker shall have a lockable operator handle mounted on the inner door. The circuit breaker shall be type FAL as manufactured by SQUARE D.
- F. Each pump shall have a three-pole circuit breaker. The breakers shall be manufactured by the same manufacturer as the NEMA rated starters.
- G. Each pump shall have a NEMA rated motor starter. The starters shall be as manufactured by SQUARE D, TYPE 8536. Each motor starter shall include melting alloy type overload heaters sized according to the motors full load amps and the SQUARE D sizing charts.
- H. Each pump shall have a hand-off-auto selector switch, run light, seal failure light and elapsed time meter mounted on the inner door. All switches and lights shall be corrosion resistant and be of the 22 MM type, as manufactured by SPRECHER & SCHUH.
- I. There shall be a termination strip with box type connectors to make all power and control connections for the pumps. All terminals shall be marked for easy identification. A ground terminal strip shall be provided also.
- J. A solid-state electronic alternator relay shall be installed to allow equal wear of the pumps. The alternator shall be arp41s as manufactured by ABB/SSAC.
- K. Pump protection monitoring relays shall be installed in the panel. These relays shall monitor the heat sensors and seal leak probes within the pumps. The heat sensor shall be wired in series with the motor starter coil and shut the pump off when in a failed condition. The alarm shall automatically reset. The seal leak monitor shall energize the seal failure indicator light on the inner door. This alarm shall be indication only and shall not shut the pump down. The pump manufacturer shall supply these monitoring relays.
- L. A 100-watt condensation heater shall be installed within the panel. It shall be manufactured by HOFFMAN, model D-AH1001A, or equal.
- M. The control panel shall have a serialized UL label. The UL label shall be a UL 698A label for industrial (508) control panels related to hazardous (classified) locations. The control panel shall be manufactured in a UL 508 panel shop.

- N. The control panel shall contain a flashing “hi water” alarm light mounted on the top of the enclosure with red shatter resistant lens and 40 watt bulb. The alarm system shall also include an audible alarm horn with silence pushbutton mounted on the side of the enclosure. The silence pushbutton shall silence the horn but the red flashing light shall remain lit until the alarm condition has cleared.
- O. Dry relay contacts shall be provided for connection to the plant SCADA system as indicated on the Process and Instrumentation Diagrams (P&ID’s) and include; Running, Failure for each pump; Moisture intrusion for each pump.

2.10 FINISHES

- A. Pump manufacturer to factory prime pump/motor as specified in Section 09960A High-Performance Coatings.
- B. CONTRACTOR to provide field coatings as specified in Section 09960A High-Performance Coatings.

2.11 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. Witnessing: Not required.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Pump shall be set in sump and shall be removable. No anchoring or bolting is required.

3.02 FIELD 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: Level 1 Pump Test as specified in Section 15958 Mechanical Equipment Testing.
- C. Vibration test: None required.
- D. Noise test: None required.

3.03 PUMP SCHEDULE

A. Pump characteristics:

Location	RAS Pump Station
Service	Accumulated Water Removal
Pump Type	Submersible Sump
Min. Capacity, gpm	10 gpm
Total Dynamic Head (TDH), Feet	12 feet
Motor Horsepower	1/3 HP min, 1 HP max
Switch Type	Float Switch

END OF SECTION

SECTION 11313

RAS PUMP AND MOTOR

PART 1 GENERAL

1.01 SCOPE

- A. This Section covers the furnishing of centrifugal pumping unit(s) as required and to the expectations of the ENGINEER with regard to the manufacture of the equipment.
- B. The RAS (return activated sludge) pump(s) specified in this Section shall be furnished by and be the product of one manufacturer. All components of the pumping unit must be supplied by and warranted by the pump OEM (original equipment manufacturer) including impellers, column, discharge heads, couplings, seals, and motors. A letter from the pump OEM must be provided as part of the submittal confirming that they accept responsibility for the warranty of the entire pumping unit. Equipment furnished under this Section shall be fabricated and assembled in full conformity with drawings, specifications, engineering data, instructions, and recommendations of the equipment manufacturer, unless exceptions are noted by ENGINEER.
- C. Except as modified or supplemented herein, all RAS pumps shall conform to the most recent edition of ANSI/AWWA E103 and Hydraulic Institute Standards.

1.02 SUBMITTALS

- A. Shop drawings shall be submitted in accordance with Section 01330 and shall include descriptive information as required to fully describe the pump, controls, and overall operating performance. The shop drawings shall clearly state any deviations from the specified requirements. The following shall also be furnished with the shop drawings. Performance requirements specified hereinafter shall be defined in the Hydraulic Institute Standards and ANSI/AWWA E101-88.
 - 1. Performance data curves (adjusted for operating speed) showing head, capacity, horsepower demand, and pump efficiency over the entire operating range of the pump, from shutoff to maximum capacity. The equipment manufactured shall indicate separately the head, capacity, horsepower demand, overall efficiency, and minimum submergence required at the specified design point.
 - 2. Equipment manufacturer shall provide complete and detailed information regarding the installation of the pumps. Any installation requirements or operating conditions which the supplier or manufacturer determines to be critical to the safe and reliable operation of the pumps should be identified and described in detail.

Operating and Maintenance Manuals and Maintenance Summary Sheets for the equipment specified herein shall be provided to the OWNER.

1.03 QUALITY ASSURANCE

- A. All pump components shall be manufactured in the United States. The motors are exempt from this requirement.
- B. The pump manufacturer shall be certified to the ISO 9001 standard for design and manufacture of centrifugal pumps.
- C. Equipment shall be manufactured in a facility that recognizes its impact on the environment and has demonstrated a commitment to the minimizing that impact by achieving ISO 14001 certification.
- D. All pressure containing fabrications shall be welded only by welders who are qualified to ASME code section 9. Welder certification shall be provided as part of the submittal package.

1.04 WARRANTY

- A. The manufacturer shall warrant their pumps to be free of defects in material and workmanship for a period of one (1) year after the product is first put into operation or eighteen (18) months after date of shipment, whichever occurs first.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. The pumps shall be adequately supported during transit to ensure the pumping unit is not subjected to undue stresses.
- B. Spare parts shall be furnished as specified. Spare parts shall be suitably packaged with labels indicating the contents of each package. Spare parts shall be delivered to OWNER as directed.
- C. Final documentation shall be delivered on compact disk, readable using Acrobat, MS Office, and Solidworks.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. KSB
- B. Or Approved Equal

Other manufacturers will be considered as long as they meet the performance and quality requirements specified within. Any "or equal" substitution must be submitted to the DESIGN ENGINEER two weeks before the bid date for approval. If approved, the manufacturer will be listed by addendum.

2.02 PERFORMANCE AND DESIGN REQUIREMENTS

- A. Pump shall be capable of continuous operation while pumping return activated sludge.

B. Pump Operating Capacity (Large RAS Pump)

1. Large RAS Pump

- a. Quantity: 1.
- b. Location: RAS Pump Station (see M-03 on plans).
- c. Pump Capacity: 700 gpm.
- d. Total Dynamic Head: 42 ft.
- e. Minimum Flow: Must be lower than capacity of the Small RAS Pumps in parallel
- f. Maximum Design Speed: 1770 RPM.
- g. Pump Operation: Variable speed.
- h. Maximum Motor: 17 HP.

2. Small RAS Pumps

- a. Quantity: 2 in parallel.
- b. Location: RAS Pump Station (see M-03 on plans).
- c. Pump Capacity: 270 gpm each, 330 gpm in parallel.*
*The pump capacity may vary as long as the two pumps in parallel have a higher flow rate than the minimum flow of the Large RAS Pump.
- d. Total Dynamic Head: 15 ft.
- e. Minimum Flow: 50 gpm.
- f. Maximum Design Speed: 1190 RPM.
- g. Pump Operation: Variable speed.
- h. Maximum Motor: 3 HP.

C. Pumping units shall be designed for the performance and design requirements as required, at maximum speed unless otherwise noted.

D. For design and rating purposes, the water to be pumped shall be assumed to have a temperature of 70°F.

E. The pumping application required for this project demands equipment that will operate reliably for many years. Unscheduled downtime is unacceptable to the client, and it is the objective of this specification to deliver the highest quality equipment that is fit for purpose.

2.03 PUMP CONSTRUCTION

A. PUMP MATERIALS

- 1. All pump materials shall be as specified or may be a pre-approved alternative.
- 2. Casing, Back Plate, and Impeller
 - a. Cast Iron, ASTM A48, Class 35B
 - b. Duplex Stainless Steel, ASTM A743 Type CD4Mcu
 - c. High Chrome White Iron, ASTM A532 IIC 15% CrMo-Hc
- 3. Pump Shaft
 - a. Stainless Steel, ASTM A276 Type 420
 - b. Duplex Stainless Alloy, ASTM A182-FXM19
- 4. Bearing Bracket
 - a. Cast Iron, ASTM A48, Class 35B
- 5. Gaskets and Seal Elastomers
 - a. NBR

- b. Viton
- 6. Fasteners
 - a. Stainless Steel, ASTM A276 Type 3000
- 7. Seal Faces
 - a. Silicon Carbide
- B. GENERAL DESCRIPTION
 - 1. The pump shall be centrifugal, single stage, end suction / radial discharge type with centerline discharge. The pump shall be designed as “back pull-out” such that the entire rotating assembly can be removed without disturbing the suction and discharge connections.
- C. INSTALLATION CONFIGURATION
 - 1. The pump shall be designed for installation in a horizontal position, driven directly by an integrally coupled horizontal C-face motor.
- D. DRIVE MOTOR
 - 1. The drive motor shall be NEMA B design, rated for continuous duty at 400C, in a horizontal “TC” frame. The motor shall be mounted on a suitable face flange on the pump bearing frame, with its shaft inserted into the pump shaft. The motor shall be removable from the pump without the need to remove the pump impeller or backplate.
- E. MAJOR COMPONENTS
 - 1. Furnish major components (pump case, impeller, backplate, bearing bracket) of cast material as specified with smooth surfaces devoid of blow holes and other irregularities.
- F. CLEAN-OUT PORT
 - 1. All pumps with discharge size of 4” or larger shall include a minimum 4-5/8” diameter clean out aperture cast into the pump case near the cutwater. The clean out aperture cover shall be cast of the same material as the pump case and shall extend completely through the pump case with an inside contour to match the case. The cover shall fasten to a flange cast onto the pump case and shall be sealed with an o-ring. Fabricated (non-cast) cover plates, covers not contoured to match the casing, or covers with flat gasket seals will not be considered as acceptable.
- G. IMPELLER
 - 1. The impeller shall be statically and dynamically balanced, capable of passing the minimum solid size specified above. Back vanes shall BE provided to minimize axial loads and to propel solids away from the seal area.
- H. PUMP SHAFT
 - 1. The pump shaft shall be of sufficient size to transmit full driver output with a maximum deflection of 0.002 inches measured at the outer mechanical seal.
- I. SPECIAL TOOLS AND ACCESSORIES

1. Equipment requiring periodic repair and adjustment shall be furnished complete with all special tools, instruments, and accessories required for proper maintenance. Equipment requiring special devices for lifting or handling shall be furnished complete with those devices.

J. SPARE PARTS

1. If required, to be specified by the ENGINEER and/or OWNER.

PART 3 EXECUTION

3.01 FIELD QUALITY CONTROL

- A. An experienced, competent, authorized representative of the manufacturer shall visit the site of the Work and inspect, check, adjust if necessary, and approve the equipment installation. The representative shall be present when the equipment is placed in operation and shall revisit the job site as often as necessary until all trouble is corrected and the equipment installation and operation are satisfactory in the opinion of ENGINEER.
- B. The manufacturer's representative shall furnish a written report certifying that the equipment has been properly installed and lubricated; is in accurate alignment; is free from any undue stress imposed by connecting piping or anchor bolts; and has been operated under full load conditions and that it operated satisfactorily.
- C. All costs of these services shall be included in the contract price for the number of days and round trips to the site as required.
- D. The equipment manufacturer shall furnish a qualified field installation supervisor during the equipment installation. Such services shall be included in the contract price for the number of days and round trips to the site as required.
- E. Manufacturers' installation supervisor shall observe, instruct, guide, and direct the installing contractor's erection or installation procedures. The equipment manufacturer will be provided with written notification 10 days prior to the need for such services.
- F. Tests shall be performed in accordance with the Test Code for Centrifugal Pumps per the Standards of the Hydraulic Institute. Tests shall be performed on the actual assembled pumps to be supplied or on duplicate previously constructed models. Tests shall cover a range from shut-off to at minimum 20% beyond specified design capacity. Conduct test per above specification on all supplied pumps, generating a curve showing actual flow, head, BHP, and hydraulic efficiency.
- G. The contractor shall field test all pumps after installation to demonstrate satisfactory operation without excessive noise, vibration, cavitation, or over-heating. Any pump which fails to meet any of the contract specifications will be modified, repaired, or replaced by the contractor at no additional cost to the owner.

END OF SECTION

11313-6

SECTION 11392

FLOATING BRUSH AERATOR

PART 1 GENERAL

1.01 EQUIPMENT OVERVIEW

- A. These Specifications provide the requirements to furnish, deliver and place into operation floating brush aerators at Tuolumne City Sanitary District's WWTP.
- B. The design, fabrication, supply, and installation of the aeration system shall be as specified herein.
- C. Floating brush aerators shall be equipped with all necessary equipment and materials to meet the specified requirements in the proposed wastewater treatment process.

1.02 REFERENCES

- A. Occupational Safety and Health Administration, OSHA.
- B. Department of Transportation, DOT.

1.03 QUALITY ASSURANCE

- A. Continuous Operation Equipment. The equipment shall operate continuously, all day and all night, 365 days per year, and have a 25-year design life. This equipment warranty will run directly from the manufacturer of the equipment to the OWNER. The equipment warranty will not be part of the contract or any required bond.
- B. No Visual Defects. The equipment shall have no visual defects, and shall have high quality welds and assembly, corrosion resistant finish, and site-specific operational controls.
- C. Qualified US Manufacturer. The manufacturer of the equipment shall have extensive experience in the production of such equipment, and the equipment shall be manufactured in the continental United States. The aeration system supplier shall be experienced in wastewater treatment processes and shall be prepared to demonstrate the effect on the client's process of the aeration systems supplied through documented analysis relating to flow, hydraulic retention time, and biological contact.
- D. Factory Startup Services. Delivery, placement, and startup services shall be included in the bid and performed by full time factory employees experienced in the operation of this equipment and who have completed OSHA safety trainings applicable to this type of work

- E. Warranty. The aeration equipment shall be warranted to be free of defects in materials and workmanship for a period of 12 months from the date of original placement. In addition, the motor shall be warranted for a period of 10 years. A copy of the warranty shall be included with the submittal. This equipment warranty will run directly from the manufacturer of the equipment to the OWNER. The equipment warranty will not be part of the contract or any required bond.

1.04 SUBMITTALS

- A. The Manufacturer shall provide the CONTRACTOR submittals showing full details of all aeration equipment and appurtenances.
- B. The awarded BIDDER shall provide five (5) copies of the following documents. Upon acceptance of these documents by the ENGINEER, the BIDDER will be issued a Notice to Proceed, and may then proceed to furnish the equipment.
 - 1. Certified Oxygen Transfer & Mixing Tests performed by an independent third party. These tests should support the aeration system design and show the aeration system can provide the oxygen & mixing necessary for proper and effective wastewater treatment.
 - 2. A copy of the circulation equipment warranty in compliance with Section 1.03 of this document.
 - 3. Detail drawings showing plan and elevation dimensions of the proposed equipment and appurtenances to be furnished, in compliance with Section 2.02.
 - 4. Manufacturer's literature, illustrations, and specification sheets.
 - 5. Electrical requirements, including power and control wiring schematics. Failure to submit the above data as set forth shall be cause for rejection of the submittal and equipment.

1.05 FIELD SERVICES

- A. Factory Personnel. The placement and startup shall be performed by full time factory employees trained in the operation of the circulation equipment.
- B. Safety. Technicians shall have received job-specific safety training on (a) Working over Water, (b) Boating Safety, (c) Disinfecting Procedures, (d) Confined Space Entry, (e) Fall Protection, and (f) DOT Compliance.

PART 2 PRODUCT

2.01 MANUFACTURER

- A. Specified Equipment. The circulation equipment shall be manufactured by ECS House Industries, Inc., Cherry Valley, Arkansas or be a pre-approved alternative.
- B. Pre-approved Alternative(s).

Note: This specification was developed using design criteria from House Industries. Other manufacturers will be considered as long as they meet the performance and quality requirements specified within. Any "or equal" substitution must be submitted to

the DESIGN ENGINEER two weeks before the bid date for pre-approval. If approved, the manufacturer will be listed by addendum.

2.02 PERFORMANCE AND FEATURES

- A. The CONTRACTOR will install a total of two (2) 20 hp floating brush aerators as shown in the design documents. The aerators must be capable of completely mixing the sludge lagoon 24 hours per day X 365 days/year.
- B. Floating Brush Aerator Rotor Assembly.
 - 1. The 20 hp floating brush aerator rotor shall have a 16" standard wall rotor pipe. The rotor shall be 120" in length. The rotor shall have 171 brushes that are 6" wide x 11-5/16" long. The brushes shall have a 133-degree V-shaped angle. The brushes shall be robotically welded, on both sides, in a spiral configuration to achieve superior balance and rotation. The rotor assembly shall be constructed from TGIC Powder Coated, ASTM A36 Steel.
 - 2. The rotor assembly shall have welded-in CNC machined inner plates that allow both the drive and non-drive end shafts the ability to be bolted-into the rotor. The bolt-in shafts are the "male" parts and the machined inner plates are the "female" parts. This is a definition of a piloted, bolt-in shaft assembly. A welded-flange on the outer diameter of the rotor pipe or torque tube with a bolted-on shaft is not acceptable. The drive and non-drive end shaft shall be fabricated from 316 stainless steel.
- C. Drive Train Double Seal Protection System.
 - 1. The "Double-Seal Protection" (DSP) system prevents wastewater, solids in the wastewater, and corrosive wastewater gases from entering the drive-train enclosure. The DSP ensures that the drive-train (flange bearing, gear reducer, paraflex coupler, & electric motor) will not be exposed to the elements described above.
 - 2. The DSP system begins as the 316 stainless steel drive shaft enters the DSP enclosure through inner & outer seal plates. The 20hp floating brush aerator shall have a 3-7/16" diameter drive shaft.
 - 3. The piloted-inner and outer seal plates shall be CNC machined from ASTM A36 steel. The inner and outer seal plates shall have spring loaded, non-metallic, double-lip nitrile seals. The cavity between the inner and outer seal plates are grease filled through a port on the side of the outer seal plate. Internally, the 20hp drive shaft is supported by a 3-7/16" piloted flange bearing that is bolted internally to the DSP drive case with a spacer ring that permits a close fit and aligns the shaft seals.
 - 4. The piloted, flange bearing shall have a minimum L10 rating of 100,000 hours. The piloted, flange bearing and gear reducer output hub bearings support the weight of the drive-end rotor assembly. This 20hp drive shaft reduces diameter to 3-3/16" to permit mounting of the gear reducer to the drive shaft via a tapered bushing assembly. A Perma-Lube, battery operated grease feeder shall be provided with each floating brush aerator to lubricate the non-drive end bearing. The Perma-Lube provides grease to the bearing as needed. The requires a manual grease cartridge and battery change every three (3) months. The frequency for this refill is located in the O&M Manual.

5. The DSP housing is fabricated from ASTM A36, TGIC Powder Coated Steel. The housing consists of : welded drive case, drive case cover with a glued neoprene seal and hinge linkage, vented motor mounting bracket, motor height adjusting brackets with stainless steel adjusting bolts, vent hole splash prevention angle, 16 gauge, 304L stainless steel motor cover, stiffening angles bolted to the upper case sides and ends, and anti-rotation angles that lock the gear reducer into position after the motor and gear reducer input shafts are aligned. The stiffening angle closest to the rotor assembly shall provide an adjustable hinge point for compression of the seal around the top edge of the enclosure, enclosure sides, and motor bracket.
6. The motor bracket bolts directly to the DSP housing to provide room for installation and removal of the shaft mounted gear reducer. The motor is sealed to the DSP housing with silicone. This assembly ensures that the C-Face motor can be removed without having to reposition the gear reducer.
7. The cover of the DSP housing shall be held closed with two stainless steel clamp latches mounted on stainless steel blocks bolted to the DSP housing sides. The latching force shall be adjustable to maximize sealing of the cover. The stainless-steel clamp catches shall be bolted to the DSP cover flange. When in the raised position for service and inspection, the cover shall be held open with manually inserted stainless steel pins with lanyard in the hinge linkage.
8. The DSP housing shall be bolted to the framework in four (4) places provided by four (4) angle brackets bolted to the DSP housing sides.

D. Gear Reducer.

1. The gear reducer shall be a constant-duty AGMA Class III DODGE gear reducer. The gear reducer shall be directly mounted to the rotor assembly's drive shaft with a tapered-bushing assembly. The shaft mounted helical gear reducer shall have tapered roller bearings. Ball bearings in the gear reducer are not acceptable. The gear reducer shall produce a nominal rotor speed of 70 rpm.
2. The 20hp floating brush aerator will have the DODGE TA5 model gear reducer. The TA5 gear reducer shall be rated for 57.4hp @ 1750 RPM input speed, providing a minimum 2.0 service factor.
3. The input shaft and output hub seals shall be non-corrosive, non-metallic, stainless steel spring loaded double lip, nitrile seals. The output hub shall have two seals on each side.
4. A cooling fan shall be mounted to input shaft of the gear reducer. A keyed hub on the input shaft will provide rotating power for the fan.

E. Raptor Coupling.

1. The input shaft of the gear reducer shall be connected to the motor shaft with a Dodge Raptor Coupler. This direct-driven assembly between the electric motor and gear reducer via a Raptor coupler provides a "Dampened Drive System" (DDS). The DDS absorbs start-up forces and allows for 4° of misalignment. The coupler shall be high speed. The gear reducer shall not be connected to the motor using any type of V-belt driven system or a "low speed coupled" direct driven system.
2. The 20hp floating brush aerator uses an E20 Dodge Model Coupler.

F. Electric Motor.

1. Each floating brush aerator shall use a premium efficiency, severe-duty C-face motor with mounting feet. The motors shall be 20hp, 3-phase, 60 Hertz, 230/460 volt, 1750 RPM with a 1.25 operating service factor when motor is operating at 90% of rated full load during normal operation.
2. Motor(s) shall be totally enclosed, fan cooled (TEFC), rated for severe corrosive-duty, NEMA Class F insulation, cast iron construction with an epoxy coating, and stainless-steel hardware and nameplate. (Premium efficiency; meets or exceeds the requirements of EPACT '92 and Canadian Federal Efficiency Levels defined in CSA C390-93. Full load efficiency of all ratings is certified under the EEV Program of the CSA.)
3. The aerator manufacturer shall provide certification that the nameplate data affixed to the aerator's electric motor is valid, specific data applicable to that particular motor.

G. Non-Drive End Rotor Bearing.

1. The non-drive end bearing shall be a grease lubricated, stainless steel, eccentric collar, ball-bearing assembly. The bearing shall have a 304L stainless steel inspection cover and an auxiliary, non-corrosive seal mounted in a 304L stainless steel seal plate on the rotor assembly side of the non-drive end bearing bracket.
2. The eccentric collar shall have a stainless steel, rear cover mounted above and around the non-drive end bearing bracket sides.
3. The bearing shall have an L10 bearing life over 100,000 hours.
4. A Perma-Lube, battery operated grease feeder shall be provided with each floating brush aerator to lubricate the non-drive end bearing. The Perma-Lube provides grease to the bearing as needed. The requires a manual grease cartridge and battery change every three (3) months. The frequency for this refill is in the O&M Manual.
5. Plastic bearings that may or may not use wear sleeves or bushings will not be acceptable. Water lubricated bearings are also not acceptable.

H. Flotation Assembly.

1. Each floating brush aerator shall have (2) two, 16 gauge, 304L stainless steel tanks. All stainless-steel floats shall be seam welded and pressure checked after fabrication. The stainless-steel floats shall be foam filled with "closed celled" two part foamular foam.
2. The 20hp drive-end tank shall be 10' long x 29" diameter, and the non-drive end tank shall be 10' long x 29" diameter.

I. Splash Shields.

1. Each aerator shall have splash shields that will protect the drive train assembly and non-drive end bearing assembly.
2. The splash shields will eliminate splash and debris from accumulating around the drive and non-drive end shafts.
3. The shrouded, sealing system will also serve as extra protection to eliminate wastewater and wastewater debris from damaging seal surfaces that are essential in the aerator's operational capacity.
4. The splash shields shall be constructed of, TGIC Powder Coated, 304L stainless steel.

J. Flotation Attachment Bands.

1. Each flotation tank shall be attached to the floating brush aerator mainframe using 304L stainless steel bands. The bands are connected to the mainframe with stainless steel pins and 304L stainless steel bolted brackets. The mainframe shall be connected to the anchoring system in such a manner that external forces, resulting from wave action and other external movement, are not transferred to the flotation attachment bands.
2. Each flotation tank shall have adjusting linkage attached to each corner of the aerator main frame. Adjusting linkage shall be capable of changing the operating depth of the horizontal rotor blades; the horsepower requirement and amperage draw, and provide aerator leveling. Adjusting linkage shall be fabricated from 304L stainless steel rods with brass adjusting nuts. Adjusting linkage shall not be connected directly to the anchoring system nor shall it mechanically depend upon the anchoring system for it to be effective.

K. Aerator Main Frame.

1. The main frame of the aerator shall be fabricated from ASTM a36, TGIC Powder Coated steel, and shall use 4" schedule 40 pipe & 3/16" plate. The frame shall be welded and bolted together with stainless steel hardware.

L. Anchoring System.

1. The anchoring system shall hold the aerator firmly in position. The type of anchoring system to be used is determined by the placement of the floating brush aerator(s), and the wastewater application.
2. The anchors shall be constructed from hot dip galvanized steel and bolted to the sludge lagoon using 5/8" epoxy anchors. Two anchors shall be installed for each floating brush aerator at three elevations: 2548 feet ASL, 2544 feet ASL, and 2540 feet ASL.
3. The anchoring poles shall be 18 feet long and fabricated from ASTM A36, TGIC Powder Coated Steel.
4. The electrical cable must be adequate length for all three floating brush aerator positions.
5. The anchoring system shall not restrict the unit's flotation and shall allow for continuous aerator operation with fluctuations in the water surface elevation up to (plus/minus) three feet (± 3 ft.).
6. The anchoring system will be determined based on ENGINEER'S drawings.

PART 3 EXECUTION

3.01 PLACEMENT

- A. The floating brush aerators shall be installed as shown on the drawings and in strict accordance with the manufacturer's instructions.
- B. The floating brush aerator manufacturer shall provide Placement, Startup, and On-Site Water Testing Services to insure (a) proper machine spatial placement in the reservoir, and (b) proper intake depth setting.

- C. The field services shall be performed by full time factory employees experienced in the operation of this equipment, and who have completed safety trainings required for this type of work in compliance with OSHA regulations including (a) Working over Water, (b) Boating Safety, (c) Disinfecting Procedures, (d) Confined Space Entry, (e) Fall Protection, and (f) DOT Compliance.
- D. After completion of the equipment installation, testing of the floating brush aerators shall be done continuously for a period of 24 hours.
- E. Within 30 days following equipment placement, the manufacturer shall provide a report detailing as described in submittal section.

END OF SECTION

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.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the CONTRACTOR'S responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR'S Work.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01612 - Seismic Design Criteria.
 - b. Section 01660 - Installation, Testing, and Commissioning.
 - c. Section 01730 - Operation and Maintenance Information.
 - d. Section 01770 - Project Closeout.
 - e. Section 03600 - Grouting.
 - f. Section 05120 - Structural Steel.
 - g. Section 09960A - High-Performance Coatings.
 - h. Section 10400 - Signage.
 - i. Section 15958 - Mechanical Equipment Testing.

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 Manufacturers 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):
 - 1. A 36 - Standard Specification for Carbon Structural Steel.
 - 2. A 48 - Standard Specification for Gray Iron Castings.

3. A 125 - Standard Specification for Steel Springs, Helical, Heat-Treated.
4. A 536 - Standard Specification for Ductile Iron Castings.
5. A 653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
6. B 61 - Standard Specification for Steam or Valve Bronze Castings.
7. B 62 - Standard specification for Composition Bronze or Ounce Metal Castings.
8. B 505 - Standard Specification for Copper Alloy Continuous Castings.
9. B 584 - Standard Specification for Copper Alloy Sand Castings for General Applications.

E. Food and Drug Administration (FDA).

F. Hydraulic Institute (HI):

G. National 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. Provisions specified under each technical equipment specification prevail over and supersede conflicting provisions as specified in this Section.
 2. Provide equipment and parts that are suitable for stresses, which may occur during fabrication, transportation, erection, and operation.
 3. Provide equipment that has not been in service prior to delivery, except as required by tests.
 4. Like parts of duplicate units are to be interchangeable.
 5. When 2 or more units of equipment for the same purpose are required, provide products of same manufacturer.
 6. 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.
 7. 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. Power transmission systems:
1. Power transmission equipment: V-belts, sheaves, shaft couplings, chains, sprockets, mechanical variable-speed drives, variable frequency drives, gear reducers, open and enclosed gearing, clutches, brakes, intermediate shafting, intermediate bearings, and U-joints are to be rated for 24 hour-a-day continuous service or frequent stops-and-starts intermittent service, whichever is most severe, and sized with a minimum service factor of 1.5:
 - a. Apply 1.5 service factor to nameplate horsepower and torque of prime source of power and not to actual equipment loading.
 - b. Apply service factors higher than 1.5 when recommended for continuous 24 hour per day operation and shock loadings in accordance with AGMA 6001-E08, other applicable AGMA standards, or other applicable referenced standards.
 - c. When manufacturer recommends service factor greater than 1.5, manufacturer's recommendation takes precedence.
- D. 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.

- E. 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. Provide jacking screws in bases and supports for equipment weighing over 1,000 pounds.
 - 4. Anchorage of equipment to concrete: Perform calculations and determine number, size, type, strength, and location of anchor bolts or other connections.
 - 5. Provide bolt sleeves for anchor bolts for heavy equipment.
 - a. Adjust bolts to final location and fill sleeve with non-shrink grout.
 - 6. 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.
 - 7. 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.
- F. 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.
- G. 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 where the Project is located.
- D. Quality control submittals:
 - 1. Source quality control reports and certified test data as specified in Section 15958 Mechanical Equipment Testing.
 - 2. Submit factory test reports before shipment.
 - 3. Certified static and dynamic balancing reports for rotating equipment.
 - 4. Field quality control reports and test data as specified in Section 15958 Mechanical Equipment Testing.
 - 5. Submit material test reports as specified in the equipment sections.

- E. Operation and maintenance manuals:
 - 1. As specified in Section 01730 Operation and Maintenance Information.
 - 2. Submit prior to training of OWNER'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.

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.
3. Functional testing requirements as specified in Sections 15958 Mechanical Equipment Testing.

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 belts:

1. When spare belts are specified, furnish 1 spare belt for every different type and size of belt-driven unit:
 - a. Where 2 or more belts are involved, furnish matched sets.
 - b. Identify as to equipment, design, horsepower, speed, length, sheave size, and use.
 - c. Package in boxes labeled with identification of contents.

C. Spare parts:

1. Assume responsibility until turned over to OWNER.
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.

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.
4. Galvanized steel sheet: ASTM A 653, minimum 0.0635 inch (16 gauge).
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: As specified in Section 05120 Structural Steel; 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).
 - e. Double seal applications: Plan 54 (External seal water).

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.
2. Drinking water service:
 - a. Approved by the FDA or NSF.
 - b. Asbestos free.

- c. Material: Braided PTFE (Teflon).
 - d. Manufacturers: One of the following or equal:
 - 1) Chesterton, 1725.
 - 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.
 - c. O-ring: Viton 747.
 - d. Gland: Type 316L stainless steel.
 - e. Set screws: Type 316L stainless steel.
 - f. Faces: Reaction bonded, Silicon Carbide.
 - 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, 3710.

2.04 GEAR REDUCTION UNITS

- A. Type: Helical or herringbone, unless otherwise specified.
- B. Design:
 - 1. Made of alloys treated for hardness and for severe service.
 - 2. AGMA Class II service:
 - a. Use more severe service condition when such is recommended by unit's manufacturer.
 - 3. Cast iron housing with gears running in oil.
 - 4. Anti-friction bearings.
 - 5. Thermal horsepower rating based on maximum horsepower rating of prime mover not actual load.
 - 6. Manufactured in accordance with applicable AGMA standards.
- C. Planetary gear units are not to be used.

2.05 BELT DRIVES

- A. Sheaves:

1. Separately mounted on bushings by means of at least 3 pull-up bolts or cap tightening screws.
 2. When 2 sheave sizes are specified, provide separate belts sized for each set of sheaves.
 3. Statically balanced for all; dynamically balanced for sheaves that operates at peripheral speed of more than 5,500 feet per minute.
 4. Key bushings to drive shaft.
- B. Belts: Anti-static type when explosion-proof equipment or environment is specified.
- C. Manufacturers: One of the following or equal:
1. Dodge, Dyna-V belts with matching Dyna-V sheaves and Taper-Lock bushings.
 2. Wood's, Ultra-V belts with matching Sure-Grip sheaves and Sure-Grip bushings.

2.06 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 at 125 degrees Fahrenheit.
 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.

2.07 SAFETY GUARDS

- A. Drive assemblies: Enclose sprockets, belts, drive chains, gearings, couplings, and other moving parts on drive assemblies in safety enclosures that are in compliance with applicable Laws and Regulations.

- B. Shafts: Provide guards that protect personnel from rotating shafts or components within 7.5 feet of floors or operating platforms.
- C. Guard requirements:
 - 1. Allow visual inspection of moving parts without removal.
 - 2. Allow access to lubrication fittings.
 - 3. Prevent entrance of rain or dripping water for outdoor locations.
 - 4. Size belt and sheave guards to allow for installation of sheaves 15 percent larger and addition of 1 belt.
- D. Materials:
 - 1. Sheet metal: Carbon steel, 12-gauge minimum thickness, hot-dip galvanized after fabrication.
 - 2. Fasteners: Type 304 stainless steel.

2.08 SPRING VIBRATION ISOLATORS

- A. Design requirements:
 - 1. Telescopic top and bottom housing with vertical stabilizers to resist lateral and vertical forces.
 - 2. Use steel coil springs.
 - 3. Design vibration isolators in accordance with seismic design criteria as specified in Section 01612 Seismic Design Criteria.
- B. Manufacturers: One of the following or equal:
 - 1. California Dynamics Corporation, Type RJSD.
 - 2. Mason Industries, equivalent product.
- C. Materials:
 - 1. Fabricate isolators using welded steel or shatterproof ductile iron in accordance with ASTM A 536 Grade CS-45-12.
 - 2. Spring steel: ASTM A 125.

2.09 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.

2.10 FABRICATION

- A. Structural steel members: As specified in Section 05120 Structural Steel.
- B. 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.
- C. 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.
- D. Shop finishing:
1. Provide factory and field coating as specified in Section 09960A High-Performance Coatings. If not specified in Section 09960A 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.
 - d. Coating for ferrous metal surfaces, except stainless steel: High solids polyamine epoxy.
 - e. Finish painting of motors: Shop finish paint with manufacturer's standard coating, unless otherwise specified in Section 09960A High-Performance Coatings.

2.11 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 headboxes 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 01660 Installation, Testing, and 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 01660 Installation, Testing, and Commissioning.

END OF SECTION

SECTION 15052

COMMON WORK RESULTS FOR GENERAL PROCESS PIPING

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Basic piping materials and methods.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the CONTRACTOR'S responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR'S Work.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
 - a. Division 1 - General Conditions.
 - b. Section 09960A - High-Performance Coatings.
 - c. Section 15061 - Pipe Supports.
 - d. Section 15066 - Steel Pipe.
 - e. Section 15211 - Ductile Iron Pipe.
 - f. Section 15247 - Polyvinyl Chloride Gravity Pipe.

1.02 REFERENCES

- A. American Society of Mechanical Engineers (ASME):
 - 1. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 Through 24.
 - 2. B16.47 - Large Diameter Steel Flanges: NPS 26 Through NPS 60 Metric/Inch Standard.
- B. American Water Work Association (AWWA):
 - 1. C207 - Standard for Steel Pipe Flanges for Waterworks Services-Size 4 Inches through 144 Inches.
- C. ASTM International (ASTM):
 - 1. A 193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications.
 - 2. A 194 - Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
 - 3. A 307 - Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.

4. F 37 - Standard Test Methods for Sealability of Gasket Materials.

D. California Health and Safety Code.

1.03 DEFINITIONS

A. Buried pipe: Pipe that is buried in the soil, or cast in a concrete pipe encasement that is buried in the soil.

B. Exposed pipe: Pipe that is located aboveground, or pipe that is located inside a structure, supported by a structure, or cast into a concrete structure.

C. Underground piping: Piping actually buried in soil or cast in concrete that is buried in soil.

D. Underwater piping: Piping below tops of walls in basins or tanks containing water.

E. Wet wall: Wall with water on at least 1 side.

1.04 SUBMITTALS

- A. Product data:
1. Escutcheons.
 2. Link -type seals.
 3. Flange bolts.
 4. Gaskets.

PART 2 PRODUCTS

2.01 ESCUTCHEONS

A. Material: Chrome-plated steel plate.

- B. Manufacturers: One of the following or equal:
1. Dearborn Brass Company, Model Number 5358.
 2. Keeney Manufacturing Company, Model Number 102 or Number 105.

2.02 LINK TYPE SEALS

- A. Characteristics:
1. Modular mechanical type, consisting of interlocking neoprene or synthetic rubber links shaped to continuously fill the annular space between the pipe and wall opening.
 2. Assemble links solely with stainless steel bolts and nuts 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.
- B. Manufacturers: One of the following or equal:
1. Calpico, Incorporated.

2. Pipeline Seal and Insulator, Inc., Link-Seal.

2.03 FLANGE BOLTS

A. Ductile iron pipe:

1. Bolts and nuts for ductile iron pipe flanges located indoors, outdoors above ground, or in dry vaults and structures shall be carbon steel, ASTM A 307, Grade B.
2. Bolts and nuts for ductile iron pipe flanges located indoors, outdoors above ground, or in dry vaults and structures where the pressures exceed 150 pounds per square inch shall be alloy steel, ASTM A 193, Grade B7.
3. Bolts and nuts for ductile iron pipe flanges submerged in water or wastewater, buried, in wet vaults or structures, adjacent to wet walls, or above open water-containing structures shall be Type 316 stainless steel in accordance with ASTM A 193, Grade B8M for bolts and in accordance with ASTM A 194, Grade 8M for nuts.
4. Provide a washer for each nut. Washer shall be of the same material as the nut.
5. Nuts shall be Heavy hex-head, Type 2H.
6. Cut and finish flange bolts to project a maximum of 1/4 inch beyond outside face of nut after assembly.
7. Tap holes for cap screws or stud bolts when used.

B. Plastic pipe:

1. Bolts and nuts for flanges on plastic pipe located indoors, outdoors above ground, or in dry vaults and structures shall be carbon steel, in accordance with ASTM A 307, Grade B.
2. Bolts and nuts for flanges on plastic pipe submerged in water or wastewater, buried, in wet vaults or structures, adjacent to wet walls, or above open water-containing structures and plastic pipe carrying corrosive chemicals shall be Type 316 stainless steel in accordance with ASTM A 193, Grade B8M for bolts and in accordance with ASTM A 194, Grade 8M for nuts.
3. Provide a washer for each nut. Washer shall be of the same material as the nut.
4. Nuts shall be Heavy hex-head.
5. Cut and finish flange bolts to project a maximum of 1/4 inch beyond outside face of nut after assembly.
6. Tap holes for cap screws or stud bolts when used.

C. Steel pipe:

1. Bolts and nuts for ASME B16.5 Class 150 flanges and AWWA C207 Class D flanges located indoors, outdoors above ground, or in dry vaults and structures shall be carbon steel, ASTM A 307, Grade B.
2. Bolts and nuts for ASME B16.5 and B16.47 Class 300 flanges and AWWA C207 Class E and F flanges located indoors, outdoors above ground, or in dry vaults and structures in accordance with ASTM A 193, Grade B7 for bolts and in accordance with ASTM A 194, Grade 7 for nuts.
3. Bolts and nuts for flanges submerged in water or wastewater, buried, in wet vaults or structures, adjacent to wet walls, or above open water-containing structures shall be Type 316 stainless steel in accordance with ASTM A 193, Grade B8M for bolts and in accordance with ASTM A 194, Grade 8M for nuts.
4. Provide a washer for each nut. Washer shall be of the same material as the nut.

5. Nuts shall be Heavy hex-head, Type 2H.
6. Cut and finish flange bolts to project a maximum of 1/4 inch beyond outside face of nut after assembly.
7. Tap holes for cap screws or stud bolts when used.

2.04 GASKETS

- A. 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 or less than 250 degrees Fahrenheit, and raw sewage service.
 2. Gasket material:
 - a. Neoprene elastomer with minimum Shore A hardness value of 70.
 - b. Reinforcement: Inserted 13-ounce nylon fabric cloth for pipes 20 inch or larger.
 - 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 20 inches in diameter:
 - 1) Garlock, Style 7797.
 - 2) John Crane, similar product.
 - b. Pipe 20 inches in diameter and larger:
 - 1) Garlock, Style 8798.
 - 2) John Crane, similar product.
- B. Gaskets for flanged joints in polyvinyl chloride and polyethylene piping:
 1. Suitable for pressures equal to or less than 150 pounds per square inch gauge, with low flange bolt loadings, temperatures equal 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 flanged joints in ductile iron or steel water piping:
 1. Suitable for hot or cold water, pressures equal to or less than 150 pounds per square inch gauge, and temperatures equal to or less than 160 degrees Fahrenheit.
 2. Material:
 - a. Neoprene elastomer, compressed, with non-asbestos fiber reinforcement.
 3. Manufacturers: One of the following or equal:
 - a. Garlock, Bluegard 3300.
 - b. John Crane, similar product.
- D. Provide gaskets suitable for the specific fluids and pressure and temperature conditions.

2.05 LEAD-FREE MATERIALS

- A. Pipe, pipe or plumbing fittings or fixtures, solder, or flux used to convey water for human consumption shall be Lead-free as defined in Section 116875 of the Health and Safety Code.
- B. Lead-free materials in accordance with amended provisions of the Health and Safety Code shall be used on this Project.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verification of existing conditions:
 - 1. Locate and expose existing structures, piping, conduits, and other facilities and obstructions that may affect construction of underground piping before starting excavation for new underground piping and appurtenances.
 - 2. Verify sizes, elevations, locations, and other relevant features of existing facilities and obstructions. Determine conflicts for the construction of the new underground piping and appurtenances.
 - 3. Make piping location and grade adjustments to resolve conflicts between new piping and existing facilities and obstructions.

3.02 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. For 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. For piping 1 inch in nominal diameter and larger, provide sleeves with minimum inside diameters of 1 inch plus outside diameter of piping. For piping smaller than 1 inch in nominal diameter, provide sleeve of minimum twice the outside diameter of piping.
 - a. Arrange sleeves and adjacent joints so piping can be pulled out of sleeves and replaced without disturbing the structure.
 - b. Cut ends of sleeves flush with surfaces of concrete, masonry, or plaster.
 - c. Conceal ends of sleeves with escutcheons where piping runs through floors, walls, or ceilings of finished spaces within buildings.
 - d. Seal spaces between pipes and sleeves with link-type seals when not otherwise specified or indicated on the Drawings.
 - e. Seal openings around piping running through interior walls and floors of chlorine rooms and chlorine storage rooms gastight with synthetic rubber sealing compound.
 3. Provide flexibility in piping connecting to structures to accommodate movement due to soil settlement and earthquakes. Provide flexibility using details indicated on the Drawings.
- 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) Slope digester gas piping to drip traps or low-point drains at a minimum of 1/2 inch per foot where condensate flows against the gas, or at a minimum of 1/4 inch per foot where condensate flows with gas.
 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.
- E. Venting piping under pressure:
 - 1. Lay piping under pressure flat or at a continuous slope without air traps, unless otherwise indicated on the Drawings.
 - 2. Install plug valves as air bleeder cocks at high points in piping.
 - a. Provide 1-inch plug valves for water lines, and 2-inch plug valves for sewage and sludge lines, unless otherwise indicated on the Drawings.
 - 3. Provide additional pipe taps with plug cocks and riser pipes along piping as required for venting during initial filling, disinfecting, and sampling.
 - 4. Before piping is placed into service, close plug valves and install plugs. Protect plugs and plug valves from corrosion as specified in Section 09960A High-Performance Coatings.
- F. Restraining piping:
 - 1. Restrain piping at valves and at fittings where piping changes direction, changes sizes, and at ends:
 - a. When piping is underground, use concrete thrust block or mechanical restraints.
 - b. When piping is aboveground or underwater, use mechanical or structural restraints.
 - c. 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.
- G. Connections to existing piping:
1. Expose existing piping to which connections are to be made with sufficient time to permit, where necessary, field adjustments in line, grade, or fittings:
 - a. Protect domestic water/potable water supplies from contamination:
 - 1) Make connections between domestic water supply and other water systems in accordance with requirements of public health authorities.
 - 2) Provide devices approved by OWNER of domestic water supply system to prevent flow from other sources into the domestic supply system.
 2. Make connections to existing piping and valves after sections of new piping to be connected have been tested and found satisfactory.
 3. Provide sleeves, flanges, nipples, couplings, adapters, and other fittings needed to install or attach new fittings to existing piping and to make connections to existing piping.
 4. For flanged connections, provide stainless steel bolts with isolation bushings and washers, and full-face flange gaskets.
- H. Connections to in-service piping:
1. Shutdown in-service piping as specified in Division 1 General Conditions:
 - a. Establish procedures and timing in a conference attended by CONTRACTOR, ENGINEER, and OWNER of the in-service piping.
 2. Where operation and maintenance of existing facilities require that a shutdown be made during hours other than normal working hours, perform the related work in coordination with the hours of actual shutdown.
 3. Additional provisions regarding shutdown of existing facilities are specified in Division 1 General Conditions.
- I. Connections between ferrous and nonferrous metals:
1. Connect ferrous and nonferrous metal piping, tubing, and fittings with dielectric couplings especially designed for the prevention of chemical reactions between dissimilar metals.
 2. Nonferrous metals include aluminum, copper, and copper alloys.
- J. Flanged connections between dissimilar metals such as ductile iron pipe and steel pipe:
1. Provide stainless steel bolts with isolation bushings and washers, and full-face flange gaskets.

3.03 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. Cleaning potable water piping:
 - 1. Flush and disinfect potable water piping as specified in Division 1 General Conditions.
- C. Cleaning chlorine piping:
 - 1. Clean chlorine piping by pulling clean cloths saturated an approved solvent through piping:
 - a. Do not use hydrocarbons or alcohols that may react with chlorine.
 - b. Use solvents in accordance with manufacturer's safety recommendations to avoid serious physiological effects.
 - 2. Disassemble and clean valves and equipment that have oil residues before installation.
 - 3. Dry piping immediately before effecting final connections for service.
 - a. Keep piping kept sealed to prevent moisture from entering chlorine piping.
 - b. Drying procedure shall be as follows:
 - 1) Pass steam through piping from the high end until piping is thoroughly heated. While steaming, allow condensate and foreign matter to drain out.
 - 2) Stop steaming and drain pockets and low points.
 - 3) While piping is hot, blow dry air through piping until piping is dry.
 - a) Use dry air with a dew point of minus 40 degrees Fahrenheit or below.
 - 4) Continue blowing dry air through piping until exhausted air has a dew point of minus 30 degrees Fahrenheit or below.
 - 5) Allow several hours for drying piping.

3.04 PIPING SCHEDULE

See following table.

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PIPING SCHEDULE									
Code	Service								
Exposure									
Size (inches)									
	Min	Max	Materials	Joints/ Fittings	Test Pressure/ Method	Thickness or Class	Lining	Coating	Remarks
SE	Secondary Effluent								
	Buried 4	PVC 12	Gasket push-on joints	125 psig/HH	Schedule 80	N/A	N/A	See Specification 15247	
	Exposed 4	DI 12	Flanged	15 feet/GR	Class 150 or greater	Ceramic epoxy	High solids epoxy and polyurethane	See Specification 15211	
A	Air								
	Buried 1"	PVC 2"	Threaded	10 Feet / GR	Schedule 80	N/A	N/A	See Specification 15247	
RAS	Return Activated Sludge								
	Exposed 4	DI 30	Flanged	30 Feet / GR	Class 150 or greater	Cement mortar	Epoxy and polyurethane	See Specification 15211	
	Buried 4	DI 30	Restrained push-on	30 Feet / GR	Class 150 or greater	Cement mortar	2 layers of polyethylene film	See Specification 15211	
	Submerged 4	PVC 30	Flanged	30 Feet / GR	Schedule 80	N/A	N/A	See Specification 15247	
W	Water								
	Buried 0	PVC 4	Solvent Welded	150 psig/HH	Schedule 80	N/A	N/A	See Specification 15247	
	Exposed 0	Steel, galvanized 4	Grooved end or threaded	125 psig/HH		N/A	N/A	See Specification 15066	
D	Drain								
	Exposed 0	Steel, galvanized 2	Grooved end or threaded	125 psig/HH		N/A	N/A	See Specification 15066	

END OF SECTION

15052-11

SECTION 15057

FUSION BONDED EPOXY LINING

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Fusion bonded epoxy lining for steel or ductile iron pipe and fittings.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the CONTRACTOR'S responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR'S Work.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 15052 - Common Work Results for General Process Piping.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. D 1002 - Standard Test Method for Apparent Shear Strength of Single-Lap-Joint Adhesively Bonded Metal Specimen by Tension Loading (Metal-to-Metal).
 - 2. G 8 - Standard Test Methods for Cathodic Disbonding of Pipeline Coatings.
- B. Society for Protective Coatings (SSPC):
 - 1. SSPC-SP 10 - Near-White Blast Cleaning.

1.03 SUBMITTALS

- A. Product data.
- B. Test reports: Include manufacturer's certification that lining passed tests.
- C. Manufacturer's application instructions.

PART 2 PRODUCTS

2.01 EPOXY RESIN POWDER

- A. Manufacturer: One of the following or equal:
 - 1. 3M.

2. Morton Thiokol.
- B. Material: Thermosetting, fusion bonded dry powder epoxy, 100 percent solids, with following performance characteristics when applied:
 1. Cathodic disbondment resistance: Average maximum 48 millimeters when tested in accordance with ASTM G 8.
 2. Adhesion shear resistance: Minimum 4,700 pounds per square inches when tested in accordance with ASTM D 1002.

2.02 FABRICATION

- A. Blast fitting interior surfaces of pipe and fittings in accordance with SSPC-SP 10.
- B. Apply epoxy resin powder to blasted surfaces by either fluidized bed method or electrostatic coating method to obtain minimum 16-mil thick lining in accordance with manufacturer's instructions.
- C. Fuse lining to piping in accordance with manufacturer's instructions.

2.03 SOURCE QUALITY CONTROL

- A. Test lining with either 100 volt per mil thickness holiday detectors or low voltage wet sponge holiday detectors.
- B. Reject pipe and fitting with linings that contain pinholes, discontinuities or other defects.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install pipe and fitting as specified in Section 15052 Common Work Results for General Process Piping.

END OF SECTION

SECTION 15061

PIPE SUPPORTS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Supports for pipe, fittings, valves, and appurtenances.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the CONTRACTOR'S responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR'S Work.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
 - a. Division 1 - General Conditions.
 - b. Section 05120 - Structural Steel.
 - c. Section 09960A - High-Performance Coatings.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. A 380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
 - 2. A 967 - Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts.
- B. Manufacturer's Standardization Society (MSS):
 - 1. SP-58 - Pipe Hangers and Supports - Materials, Design, and Manufacture.
 - 2. SP-69 - Pipe Hangers and Supports - Selection and Application.

1.03 SUBMITTALS

- A. Shop drawings: Include schedule, indicating where supports will be installed, and drawings of pipe support system components.

PART 2 PRODUCTS

2.01 PIPE SUPPORTS

- A. Standard U-bolt: MSS SP-69, 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. Pipe clamps: MSS SP-69, 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.
- C. Adjustable offset pipe clamp:
 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 B3149.
 - 3) FM Stainless Fasteners, Figure 63.
 - b. For all other piping, unless indicated on the Drawings:
 - 1) Anvil International, Figure 100.
 - 2) Cooper B-Line Systems, Inc., Figure B3149.
- D. Offset pipe clamp:
 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) Nibco-Tolco, Figure 8.
 - 2) Cooper B-Line Systems, Inc., Figure 3148.
 - b. For all other piping, unless indicated on the Drawings:
 - 1) Anvil International, Figure 103.
 - 2) Cooper B-Line Systems, Inc., Figure B3148.
- E. Floor stand or stanchion saddles: MSS SP-69, 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.

- F. Spring hangers:
 - 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) Bergen-Power, Figure 920.
 - b. For all other piping, unless indicated on the Drawings:
 - 1) Anvil International, Figure B-268, Type G.
 - 2) Bergen-Power, Figure 920.
- G. Welded beam attachment: MSS SP-69, Type 22:
 - 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) Nibco-Tolco, Figure 304.
 - 2) Cooper B-Line Systems, Inc., Figure 3083.
 - b. For all other piping, unless indicated on the Drawings:
 - 1) Anvil International, Figure 66.
 - 2) Bergen-Power, Figure 113A or 113B.
 - 3) Cooper B-Line Systems, Inc., Figure B3083.
- H. Heavy pipe clamp: MSS SP-69, Type 4:
 - 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) Nibco-Tolco, Figure 4H.
 - b. For all other piping, unless called out otherwise on the Drawings:
 - 1) Anvil International, Figure 216.
 - 2) Bergen-Power, Figure 298.
- I. PTFE pipe slide assembly: MSS SP-58, Type 35 with lateral and vertical restraint:
 - 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) Nibco-Tolco, Figure 426.
 - b. For all other piping, unless indicated on the Drawings:
 - 1) Anvil International, Figure 257, Type 3.
 - 2) Cooper B-Line Systems, Inc., Figure B3893.
- J. Anchor bolts, concrete anchors, concrete inserts, powder-actuated fasteners, and sleeve anchors: As specified in Section 05120 Structural Steel.

2.02 MATERIALS

- A. Pipe supports:
 - 1. Stainless steel (Type 304 or 316):
 - a. Use in the following applications:
 - 1) All submerged locations, above water level but below top of wall inside water bearing structures;
 - 2) Support for stainless steel piping systems;
 - 3) Where specifically indicated on the Drawings.
 - b. Field welding and fabrication of supports is prohibited.
 - c. Shop-fabricated supports:

- 1) Finish requirements: Remove free iron, heat tint oxides, weld scale, and other impurities, and obtain a passive finished surface.
 - 2) At the shop, perform pickling and passivation on all surfaces inside and out in accordance with ASTM A 380 or A 967.
 - a) Passivation treatments using citric acid are not allowed.
 2. Hot-dip galvanized steel: Use in areas other than above and where specifically indicated on the Drawings. Hot-dip galvanize pipe supports after fabrication.
 3. Plastic, aluminum, FRP, and other miscellaneous materials: Use where specifically indicated on the Drawings.
- B. Fasteners:
1. As specified in Section 05120 Structural Steel.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Properly 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, 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.
- M. Install supports at:
 - 1. Any change in direction.
 - 2. Both sides of flexible pipe connections.
 - 3. Base of risers.
 - 4. Floor penetrations.
 - 5. Connections to pumps, blowers, and other equipment.
 - 6. Valves and appurtenances.
- N. Securely anchor plastic pipe, valves, and headers to prevent movement during operation of valves.
- O. Anchor plastic pipe between expansion loops and direction changes to prevent axial movement through anchors.
- P. Provide elbows or tees supported from floors with base fittings where indicated on the Drawings.
- Q. Support base fittings with metal supports or when indicated on the Drawings support on concrete piers.
- R. Do not use chains, plumbers' straps, wire, or similar devices for permanently suspending, supporting, or restraining pipes.
- S. Support plumbing drainage and vents in accordance with plumbing code as specified in Division 1 General Conditions.
- 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-69, 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 09960A High-Performance Coatings.

END OF SECTION

SECTION 15062

PREFORMED CHANNEL PIPE SUPPORT SYSTEM

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Preformed channel pipe support system consisting of preformed channels, fittings, straps, and fasteners engineered to support piping.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the CONTRACTOR'S responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR'S Work.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01330 - Submittal Procedures.
 - b. Section 01612 - Seismic Design Criteria.

1.02 REFERENCES

- A. American Institute of Steel Construction (AISC).
- B. American Iron and Steel Institute (AISI).
- C. Manufacturer's Standardization Society (MSS):
 - 1. SP-58 - Pipe Hangers and Supports - Materials, Design, and Manufacture.
 - 2. SP-69 - Pipe Hangers and Supports - Selection and Application.

1.03 SYSTEM DESCRIPTION

- A. Supports below the top of walls of water bearing structures: Use Type 316 stainless steel for support system components.
 - 1. Supports in other locations: Use hot-dipped galvanized components unless other materials are specifically indicated on the Drawings.

1.04 SUBMITTALS

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

- B. Shop drawings: Include layout of support system including pipe loads, selected channel size, fittings, and appurtenances.

1.05 QUALITY ASSURANCE

- A. Product standards:
 - 1. Pipe support components: In accordance with MSS SP-69.
 - 2. Pipe support materials: In accordance with MSS SP-58.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Fabricate preformed channel pipe support system using, as a minimum, parts specified below and meeting the requirements specified under Section 01612 Seismic Design Criteria.
 - 1. Manufacturers: One of the following or equal:
 - a. Unistrut, Series P1000 or P1001; P5500 or P5501.
 - b. Allied Support Systems, Power Strut, Figure PS-200 or PS-200 2TS; PS-150 or PS-i50 2TS.
 - c. B-Line Systems, Inc., Channel Type B22 or B22A; Bi2 or B12A.

2.02 ACCESSORIES

- A. Preformed channel concrete inserts: Minimum 12 inches long.
 - 1. Manufacturers: One of the following or equal:
 - a. Unistrut, Series P-3200.
 - b. Allied Support Systems, Figure 282.
 - c. B-Line Systems, Series B321.
- B. 90-degree angle fittings:
 - 1. Manufacturers: One of the following or equal:
 - a. Unistrut, P1026.
 - b. Allied Support Systems, Power Strut, P603.
- C. Pipe straps:
 - 1. For pipes 8 inches in diameter and smaller: Use 2-piece universal strap with slotted hex head screw and nut.
 - a. Manufacturers: One of the following or equal:
 - 1) Unistrut, Series P1109 through P1126.
 - 2) Allied Support Systems, PSi 100.
 - 3) B-Line Systems, Inc., Series B2000.
 - 2. For pipes greater than 8 inches in diameter: Unless different material is otherwise indicated on the Drawings use 1-piece 1 inch wide by 1/8 inch thick steel strap, hot-dip galvanized after fabrication.
 - 3. For stainless steel pipes: Use type of strap required for the pipe sizes specified above, but use Type 316 stainless steel materials.
- D. Touch-up paint galvanized surfaces:

1. Manufacturers: One of the following or equal:
 - a. Galvinox, Galvo-Weld.

E. Touch-up paint for painted surfaces: Same formulation as factory paint.

2.03 FABRICATION

- A. Hot-dip galvanize support system components after fabrication to required length and shape.
- B. Do not galvanize or paint stainless steel components.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install preformed channel concrete inserts for vertical support, quantity based on manufacturer's structural design calculations.
- B. Fasten preformed channel pipe supports to existing walls using Z-fittings and concrete anchors as indicated on Drawings.
- C. Fasten preformed channel supports to preformed channel concrete inserts embedded in ceiling using U-shaped fittings.
- D. Suspend threaded rods from concrete inserts embedded in ceiling. Support preformed channel pipe supports with threaded rods.
- E. Touchup cut or damaged galvanized surfaces.
- F. Prevent contact between pipes and support components of dissimilar metals. Utilize rubber coated, plastic coated, or vinyl coated components, stainless steel components, or wrap pipe with PVC or polyethylene tape.
- G. Install support as near as possible to concentrated loads.
- H. Install support within 2 feet horizontal and vertical changes in pipe alignment.
- I. Adjust supports or install shims to obtain specified slope or elevation.

END OF SECTION

SECTION 15066

STEEL PIPE

PART 1 GENERAL

1.01 SCOPE

- A. This Section specifies steel pipe, fittings, connections, linings, and coatings.

1.02 QUALITY ASSURANCE

A. References

1. The publications referred to hereinafter form a part of this Specification to the extent referenced. The publications are referred to in the text by the basic designation only. The latest edition of referenced publications in effect at the time of the bid shall govern, except where a specific date or edition is given below. In case of conflict between the requirements of this Section and the listed standards, the requirements of this Section shall prevail.
2. American National Standards Institute (ANSI) Publications:
 - a. ANSI B1.1 *Unified Inch Screw Threads*
 - b. ANSI B1.20.1 *Pipe Threads, General Purpose*
 - c. ANSI B16.3 *Malleable Iron Threaded Fittings*
 - d. ANSI B16.5 *Pipe Flanges and Flanged Fittings*
 - e. ANSI B16.9 *Factory-Made Wrought Steel Buttwelding Fittings*
 - f. ANSI B16.11 *Forged Fittings, Socket-Welding and Threaded*
 - g. ANSI B18.2.1 *Square and Hex Bolts and Screws*
 - h. ANSI B18.2.2 *Square and Hex Nuts*
 - i. ANSI B31.1 *Power Piping*
 - j. ANSI B31.3 *Chemical Plant and Petroleum Refinery Piping*
3. American Society of Mechanical Engineers (ASME) Publications:
 - a. ASME Section IX *Certification and Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators*
4. American Society for Testing and Materials (ASTM) Publications:
 - a. ASTM A47 *Ferritic Malleable Iron Castings*
 - b. ASTM A53 *Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless*
 - c. ASTM A105/A105M *Forgings, Carbon Steel, for Piping Components*
 - d. ASTM A106 *Seamless Carbon Steel Pipe for High-Temperature Service*
 - e. ASTM A182 *Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service*
 - f. ASTM A193 *Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service*

- g. ASTM A194 *Carbon and Alloy Steel Nuts for Bolts for High Pressure or High-Temperature Service, or Both.*
- h. ASTM A197 *Cupola Malleable Iron*
- i. ASTM A234/A234M *Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures*
- j. ASTM A269 *Seamless and Welded Austenitic Stainless Steel Tubing for General Service*
- k. ASTM A312 *Seamless and Welded Austenitic Stainless Steel Pipe*
- l. ASTM A403 *Wrought Austenitic Stainless Steel Piping Fittings*
- m. ASTM A774 *As-Welded Wrought Austenitic Stainless Steel Fittings for General Corrosive Service at Low and Moderate Temperature*
- n. ASTM A778 *Welded, Unannealed Austenitic Stainless Steel Tubular Products*
- o. ASTM F152 *Tension Testing of Nonmetallic Gasket Materials*
- 5. American Water Works Association (AWWA) Publications:
 - a. AWWA C200 *Steel Water Pipe--6 Inches (150 mm) and Larger*
 - b. AWWA C205 *Cement Mortar Protective Lining and Coating for Steel Water Pipe --4 In. and Larger--Shop Applied*
 - c. AWWA C206 *Field Welding of Steel Water Pipe*
 - d. AWWA C207 *Steel Pipe Flanges for Waterworks Services--Sizes 4 In. Through 144 In.*
 - e. AWWA C208 *Dimensions for Fabricated Steel Water Pipe Fittings*
 - f. AWWA C209 *Cold-Applied Tape Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines*
 - g. AWWA C213 *Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines*
 - h. AWWA C214 *Tape Coating Systems for the Exterior of Steel Water Pipelines*
 - i. AWWA C600 *Installation of Ductile-Iron Water Mains and Their Appurtenances*
 - j. AWWA C606 *Grooved and Shouldered Joints*
 - k. AWWA M11 *Steel Pipe --A Guide for Design and Installation*
- 6. Steel Structures Painting Council (SSPC) Specifications:
 - a. SP-10 *Near White Blast Cleaning*

B. Testing

- 1. Factory testing shall conform to the requirements of ASTM A53, ASTM A106, or AWWA C200 as applicable.

1.03 SUBMITTALS

- A. The CONTRACTOR shall submit information in accordance with Section 01330 Submittal Procedures to substantiate compliance with this specification. In addition, the following specific information shall be submitted.

B. Shop Drawings

1. Shop drawings, including details and dimensions of joints and special fittings.
- C. Calculations
 1. Pipe design calculations including buried pipe thrust restraint for all locations requiring restraints.
- D. Manufacturer's Data
 1. Manufacturer's information and catalog data for all piping systems.
- E. Certificates
 1. Affidavits of compliance with AWWA C200, AWWA C205, AWWA C209, AWWA C213, AWWA C214, ASTM A53, ASTM A106, and ASTM A312 as applicable.

1.04 DEFINITIONS

- A. Terms used in Division 15 Mechanical are defined as follows:
 1. Pipe Joint: The area approximately 12 inches each way from the centerline of the visible gap between pipe lengths.
 2. Pipe Length: The pipe between two joints; part of a pipe section.
 3. Pipe Section: The reach of pipeline between two successive manholes.
 4. Pressure Terms:
 - a. Maximum: The greatest continuous pressure at which the piping system operates.
 - b. Test: The hydrostatic or pneumatic pressure used to determine system acceptance.
 5. Piping Exposure Terms:
 - a. Buried: Pipe, which may be insulated, that is located below grade and in contact with backfill material; or pipe, which may be insulated, that is located below grade and is concrete encased.
 - b. Not Buried: Pipe that does not meet the definition of buried pipe.

PART 2 PRODUCTS

2.01 PIPE

- A. ASTM A53 - The minimum wall thickness for ASTM A53 pipe shall be Schedule 40 for pipe 10 inch diameter and less, and 3/8 inch for pipe 12 inch through 24 inch diameter. Increased shell thickness shall be provided where specified in Section 15052 Common Work Results for General Process Piping, or shown on the plans.
- B. ASTM A106 - The minimum wall thickness for ASTM A106 pipe shall be Schedule 40 for pipe 10 inch diameter and less and 3/8 inch for pipe 12 inch through 24 inch diameter. Increased shell thickness shall be provided where specified.
- C. ASTM A312 - Pipe shall be seamless, Schedule 10, 316 stainless steel in accordance with ASTM A312, and shall be annealed and passivated.

- D. ASTM A778 - Pipe shall be welded, 304L stainless steel. The minimum wall thickness for pipe 20-inch diameter and less shall be Schedule 10, and 5/16 inch for pipe larger than 20-inch diameter. Pipe shall be passivated.
- E. AWWA C200 - AWWA C200 pipe shall be straight seam. The minimum wall thickness shall be 1/4 inches for pipe 36 inches and larger. The minimum wall thickness shall be 3/16 inches for pipe smaller than 36 inches. Increased shell thickness shall be provided where specified.

2.02 FITTINGS AND APPURTENANCES

- A. Fittings and appurtenances shall be as specified or as shown on the plans.
- B. Malleable iron threaded fittings and appurtenances shall conform to the requirements of ASTM A47, ASTM A197, or ANSI B16.3.
- C. Steel fittings and appurtenances shall conform to the requirements of ASTM A234 or ASTM A105, ANSI B16.11.
- D. Fabricated steel fittings and appurtenances shall conform to AWWA C208. Fittings shall be smooth radius type. Shell thickness shall be as specified for straight pipe.
- E. Stainless steel fittings for ASTM A312 pipes shall be butt weld type, ASTM A403, Grade WP 316L, dimensions according to ANSI B16.9 or flanged with welding neck and conforming to ANSI B16.5.
- F. Fittings for ASTM A778 pipes shall be manufactured in accordance to ASTM A774 or an ASTM A403. End configuration shall be flanged or beveled for welding.
- G. Unless otherwise specified, all fittings shall be rated for pressure and loadings equal to the pipe.

2.03 CONNECTIONS

- A. Threaded Connections
 - 1. Pipe thread dimensions and size limits shall conform to ANSI B1.20.1.
- B. Flange Connections
 - 1. Flanges: Where companion flanges are used, the flanges on pipe shall be refaced to be flush with the companion flange face. Class 150 and Class 300 forged steel flanges shall be raised face conforming to ANSI B16.5. Lightweight slip-on flanges shall be plain face conforming to AWWA C207, Class B and ANSI B16.5. Unless otherwise specified, steel flanges shall be ANSI B16.5, Class 150 or AWWA C207, Class D. Plain faced flanges shall not be bolted to raised face flanges.
 - a. Flanges for stainless steel pipe shall be ANSI B16.5 150 pound flat face slip on style. Flanges shall be 304 stainless steel per ASTM A182. Flanges and unions shall be provided as needed to assemble and disassemble piping.
 - 2. Gaskets
 - a. Gaskets shall be as follows:

- 1) EPDM: ethylene-propylene-diene-terpolymer.
 - 2) Neoprene: neoprene.
 - 3) Nitrile: nitrile (Buna N).
 - 4) Neoprene Cl: neoprene with cloth insert.
 - 5) Neoprene, oil resistant: neoprene with oil-resisting characteristics.
 - 6) TFE: noncreeping tetrafluoroethylene (TFE) with insert filler.
 - 7) Compressed gasketing consisting of organic fibers (Kevlar), fillers and styrene butadiene rubber (SBR) binder.
 - 8) TFE bonded EPDM: TFE bonded to EPDM in full-face gasket having concentric-convex molded rings.
 - 9) Nylon gasketing, Garlock Style 3504, 2000 psi (ASTM F152).
- b. Gaskets for plain faced flanges shall be the full face type. Thickness shall be 1/16 inch for pipe 10 inches and less in diameter and 1/8 inch for pipe 12 inches and larger in diameter. Unless otherwise specified, gaskets for raised face flanges shall match the raised face and shall be 1/16 inch thick for pipe 3-1/2 inches and less in diameter and 1/8 inch thick for pipe 4 inches and larger. Gaskets for stainless steel flange shall be full face, 1/8 in. thick white neoprene or Buna-N.
3. Bolts: Not buried flange assembly bolts shall be SAE Grade 5, ANSI B18.2.1 hexagon head carbon steel machine bolts with ANSI B18.2.2 hot pressed heavy hexagon nuts. Threads shall be ANSI B1.1, standard coarse thread series; bolts shall be Class 2A, nuts shall be Class 2B. Bolt length shall conform to ANSI B16.5. Flange assembly bolts and nuts for submerged or buried service shall be type 316 stainless steel regardless of any other protective coating. Stainless steel flange bolts shall be 316 stainless steel, ASTM A193, Grade B8M, hex head. Nuts shall be 316 stainless steel, ASTM A194, Grade 8M, hex.
4. Insulating Flange Set: Insulating flange joints shall have 1/6-inch thick plastic, full length bolt sleeves, with 1/8-inch thick insulating washers and flat washer for each flange bolt.
- C. Welded Connections for Stainless Steel Pipes
1. Materials for welded joints shall be as follows:
 - a. Filler Metal: The bard wire to be used for the gas tungsten arc welding (GTAW) root layer shall conform to SFA 5.9 Type F-6.
 - 1) The covered electrode to be used for the subsequent shielded metal arc welding layers shall conform to SFA 5.4, F-5.
 - 2) The deposited weld metal for both bare wire and covered electrodes shall conform to Weld Metal Analysis No. A-8 of Table QW-442, Section IX of the ASME Boiler and Pressure Vessel Code.
 - 3) Filler shall be ER 316L (bare wire) and E316L-15, -16 (covered electrodes).
 - 4) Bare filler rod shall be free of grease, oil, rust or other foreign matter.
 - 5) Extreme care must be exercised in handling electrodes. Wet or damaged electrodes shall not be used. Electrodes shall be purchased in sealed metal containers. Handling of weld rods shall be in accordance with manufacturer's recommendations.
 - b. Tungsten Electrodes: The electrodes used for the GTAW process shall be 1% or 2% thoriated tungsten electrodes.

- c. Inert Gas: The shielding gas for GTAW welding shall be commercial grade argon at a minimum flow rate of 15 CFH.

- 1) The purging gas shall be commercial grade argon.

D. Bell and Spigot Joints

- 1. Joints shall be bell and spigot ends with rubber gaskets as per Section 3.6.6 of AWWA C200. Ends shall employ joint rings (Carnegie shape) fabricated to accommodate a rubber O-ring gasket seal.
- 2. Where restrained joints are specified in Section 15052 Common Work Results for General Process Piping, or noted on the plans, and other types of restrained joints are not shown or specified, then the following pipe ends may be used:
 - a. Joints shall be single weld, lap welded slip joint per AWWA C206. Alternatively, ends shall employ joint rings (Carnegie shape) fabricated to accommodate a rubber O-ring gasket seal and restrained with field welded restraint bar. The CONTRACTOR shall employ the "skip" method of welding (on rubber gasketed joints only), not to exceed 6-inch section, to prevent rubber gaskets from melting.
 - b. Plain End Pipe Fitted for Butt Straps with Field Welded Joints: Ends of pipe to be fitted with butt straps for field welded joints shall conform to manufacturer's recommendations and/or Section 3.6.5 of AWWA C200. Straight butt end straps shall be a minimum of six inches wide and 1/4 inch in thickness. Butt strap joints may be used for turns or directional changes up to two degrees (2E), where field conditions warrant with the ENGINEER'S approval.
 - c. Flanges as specified in Paragraph 2.03.C, Flange Connections of this Section.

E. Restrained Expansion Joints

- 1. The restrained expansion joints shall consist of a single-arched inner tube, body, and outer cover, and shall have flanged ends and control rods. The cover and tube material shall be neoprene. The expansion joints shall include a molded integral flange that joins the body at a true 90 degree angle. Flanges shall be drilled to ANSI B16.5, Class 150. The expansion joint shall fit snug against the mating pipe flange without voids. The expansion joint must be suitable for the conditions, temperature, and pressures associated with the project. The control rods shall comply with the guidelines as set forth in Appendix C of the Fluid Sealing Association's Rubber Expansion Joint Division Technical Handbook (Sixth Edition). The control unit assembly shall be designed for an allowable stress of 65 percent of material yield for each rod and plate. The restrained expansion joint shall be Proco Series 230, Redflex J-1, or approved equal.

2.04 PIPE LINING

A. Epoxy Lining

- 1. Where specified in Section 15052 Common Work Results for General Process Piping, pipe (including butt ends) and fittings shall be epoxy lined with not less than 10 mils of epoxy. Surfaces shall be prepared in accordance with SSPC-SP-10 and the lining applied as recommended by the manufacturer.
- 2. Epoxy lining shall be Pittsburgh Paint 97-Line DTR, or equal.

B. Fusion Epoxy Lining

1. Where specified, pipe (including butt ends) and fittings shall be fusion epoxy lined in accordance with AWWA C213. Surface preparation shall be in accordance with SSPC-SP 10. The application method shall be by the fluidized bed method and shall attain 12 mils minimum dry film thickness.
 2. Field welds, connections and otherwise damaged areas shall be patched according to the manufacturer's instructions with 3M Scotchkote 306.
 3. Fusion epoxy lining shall be 3M Scotchkote 206N, or equal.
- C. Cement Mortar Lining
1. Cement mortar lining shall be as specified in AWWA C205. Thickness of the cement mortar lining shall be as specified in Table 2 of AWWA C205.
 2. Fittings and specials larger than 24 inches, not fabricated from centrifugally lined straight sections, shall require 2-inch by 4-inch by 13-gage self-furring wire mesh reinforcement for hand-applied lining.

2.05 PIPE COATINGS

A. Fusion Epoxy Coating

1. Where specified, pipe and fittings shall be fusion epoxy coated in accordance with AWWA C213. Surface preparation shall be in accordance with SSPC-SP 10. The application method shall be by the fluidized bed method and shall attain 12 mils minimum dry film thickness.
2. Field welds, connections and otherwise damaged areas shall be coated and patched according to the manufacturer's instructions with 3M Scotchkote 206N.
3. Fusion epoxy coating shall be 3M Scotchkote 203, or equal.

B. Polyethylene Tape Coating

1. Where specified, pipe and fittings shall be coated with primer and wrapped in accordance with AWWA C214 and AWWA C209. The coating application shall be a continuous step operation in conformance with AWWA C214, Section 3. The total coating thickness shall be not less than 50 mils for pipe 24 inches and smaller and not less than 80 mils for pipe 26 inches and larger.
2. Polyethylene tape coating system shall be as specified in AWWA C214 and AWWA C209.

C. Mortar Coating

1. Shop applied in accordance with AWWA C205.

PART 3 EXECUTION

3.01 PIPE INSTALLATION

A. General

1. Pipe shall be installed in accordance with AWWA M11, Chapter 12, and as shown on the plans.

B. Support and Anchorage

1. Support and anchorage shall be provided as shown on the plans.

3.02 FITTING INSTALLATION

- A. Fittings shall be installed in accordance with the manufacturer's recommendations.

3.03 CONNECTION INSTALLATION

A. Threaded Connections

- 1. Pipe cutting, threading and jointing shall conform to the requirements of ANSI B1.20.1, and the fitting manufacturer's installation recommendations.

B. Flanged Connections

- 1. Flanges shall be installed true and plumb. Raised face flanges shall not be bolted to flat face flanges.
- 2. Pipe cutting, threading and jointing shall conform to the requirements of ANSI B31.1, and the fitting manufacturer's installation recommendations.
- 3. Where a metallic nonferrous pipe or appurtenance is connected to ferrous pipe or appurtenance, an insulating section shall be provided as specified.

C. Mechanical Coupling Connections

- 1. Mechanical couplings shall be installed in accordance with the coupling manufacturer's installation recommendations.

D. Push-On Connections

- 1. Push-on connections shall be installed in accordance with the fitting manufacturer's installation recommendations.

E. Welded Connections

- 1. Pipe shall be welded by ASME certified welders using shielded metal arc, gas shielded arc or submerged arc welding methods. Welds shall be made in accordance with the requirements of ASME Section IX, ANSI B31.1, ANSI B31.3, or AWWA C206.

F. Takedown Couplings

- 1. Takedown couplings shall be screwed unions, flanged or grooved end mechanical coupling type joints and shall be provided as specified. Flanged or grooved end joints shall be employed on pipelines 2-1/2 inches in diameter and larger. Where piping passes through walls, takedown couplings shall be provided within 3 feet of the wall, unless specified otherwise.
- 2. A union or flanged connection shall be provided within 2 feet of each threaded end valve.

G. Flexibility

- 1. Unless otherwise specified, piping 2 inches in diameter and larger passing from concrete to earth shall be provided with pipe couplings or flexible joints as specified (1) within 2 feet of the structure and (2) within 3 feet of the first joint. Where required for resistance to pressure, mechanical couplings shall be restrained in accordance with AWWA MII, paragraph 13.10, Tables 13-6 and 13-7, and Figure 13-17.

H. Dielectric Connections

1. Where a non-ferrous pipe is connected to steel pipe, dielectric unions or insulating connections shall be provided. Dielectric unions shall be EPCO, Capital, or equal.

I. Bonding Of Joints

1. Where indicated all pipe joints, other than welded joints or bolted flange joints, shall be bonded to provide an electrically continuous pipeline. Bonding jumper shall be as shown on the plans.

3.04 LINING INSTALLATION

A. Epoxy Lining

1. Epoxy linings shall be installed and patched in accordance with the lining manufacturer's recommendations.

B. Cement Mortar Lining

1. Cement mortar lining shall be installed per AWWA 205. Field apply lining at joints.

3.05 COATING

A. Couplings

1. Couplings for buried installation shall be coated and patched as specified in Section 09960A High-Performance Coatings and the coating manufacturer's instructions.

B. Mortar Coating

1. Shop apply per AWWA C205. Field apply mortar at joints.

3.06 PIPELINE ACCEPTANCE

A. Leakage Tests

1. Piping shall be tested in accordance with Section 15956 Piping System Testing.

B. Cleaning

1. After backfilling and restoration of surfaces, pipelines shall be cleaned. Pipelines 21 inches or less in diameter shall be cleaned by the sewer ball method unless the pipeline can be shown to be clean by visual inspection.

END OF SECTION

SECTION 15075
EQUIPMENT IDENTIFICATION

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Equipment nameplates.
 - 2. Special items.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the CONTRACTOR'S responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR'S Work.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
 - a. Division 1 - General Conditions.
 - b. Section 09960A - High-Performance Coatings.

1.02 SUBMITTALS

- A. Submit as specified in Division 1 General Conditions.
- B. Submit following:
 - 1. Product data.
 - 2. Samples.
 - 3. Manufacturer's installation instructions.
 - 4. Submit following as specified in Division 1 General Conditions:
 - a. Operation and Maintenance Data.
 - b. Warranty.

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:

Item	Color
Valve handwheels and levers	Red
Hoist hooks and blocks	Yellow and black stripes
Steel guard posts	In accordance with standard details

- 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 Division 1 General Conditions.

3.02 PREPARATION

- A. Prepare and coat surfaces as specified in Section 09960A High-Performance Coatings.
- B. Prepare surface in accordance with product manufacturer's instructions.

END OF SECTION

SECTION 15110

COMMON WORK RESULTS FOR PROCESS VALVES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: basic requirements for valves.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the CONTRACTOR'S responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR'S Work.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
 - a. Division 1 - General Conditions.
 - b. Section 09960A - High-Performance Coatings.
 - c. Section 15211 - Ductile Iron Pipe.

1.02 REFERENCES

- A. American Water Works Association (AWWA):
 - 1. C111/A21.11 - Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe Fittings.
- B. ASTM International (ASTM):
 - 1. A 126 - Standard Specification for Gray Iron Casting for Valves, Flanges, and Pipe Fittings.
 - 2. A 167 - Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
 - 3. A 536 - Standard Specification for Ductile Iron Castings.
- C. NSF International (NSF):
 - 1. 61 - Drinking Water System Components - Health Effects.
- D. Society for Protective Coatings (SSPC):
 - 1. SP 7 - Brush-Off Blast Cleaning.
 - 2. SP 10 - 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 Division 1 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.
 - a) Certified drawings with description of component parts, dimensions, weights, and materials of construction.
 - d. Certifications of reference standard compliance:
 - 1) Submit certification that the valves and coatings are suitable in potable water applications in accordance with NSF 61.
 - a) 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 water.
 - b. In an enclosed space above water.
 - c. In structures containing 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 09960A 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 09960A 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 UNDERGROUND VALVES

- A. Provide underground valves with flanged, mechanical, or other type of joint required for the type of pipe to which the valve is to be connected.
- B. Coating and wrapping:
 - 1. After installation, encase valves in 2 layers of polyethylene wrap as specified for ductile iron piping in Section 15211 Ductile Iron Pipe.
 - a. Ascertain that polyethylene wrapping does not affect operation of valve.

2.04 VALVE BOXES

- A. Provide cast-iron valve boxes at each buried valve to access valve and valve operators.
- B. Do not support boxes on valve, valve operator, or pipe.

- C. Boxes:
 - 1. 2-piece, fabricated of cast iron; provide cover, with asphalt varnish or enamel protective coating.
 - 2. Adjustable to grade, install centered around the upper portions of the valve and valve operator.
- D. Manufacturers: One of the following or equal:
 - 1. Tyler Pipe Industries, Inc.
 - 2. Neenah Foundry Company.

2.05 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.

END OF SECTION

15110-6

SECTION 15111

BALL VALVES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: plastic body ball valves.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the CONTRACTOR'S responsibility for scheduling and coordinating the work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR'S work.
 - 3. The following sections are related to the work described in this section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed work complies accurately with the Contract Documents.

1.02 REFERENCES

- A. American Society of Mechanical Engineers (ASME):
 - 1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
 - 2. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through 24.
- B. American Water Works Association (AWWA):
 - 1. C507 - Standard for Ball Valves 6-Inch Through 48-Inch.
- C. ASTM International (ASTM):
 - 1. A 48 - Standard Specification for Gray Iron Castings.
 - 2. A 216 - Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service.
 - 3. A 351 - 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. Shop drawings: Submit the following information as specified in Section 01330 Submittal Procedures:
1. Product data.
 2. Operation and maintenance data.

PART 2 PRODUCTS

2.01 METAL BODY BALL VALVES, LESS THAN 6-INCH SIZE

- A. Manufacturers: One of the following, or equal:
1. Apollo Valves as manufactured by Conbraco Industries, Inc.
 2. Metso Automation/Jamesbury.
 3. NIBCO, Inc.
- B. General:
1. Type: Non-lubricated, full port and capable of sealing in either direction.
 2. End connections:
 - a. Threaded or solder ends for sizes 3-inch and smaller.
 - b. Class 150 flanged for sizes larger than 3-inch.
 - 1) Flanges: In accordance with ASME B16.1 standards.
 3. Stem packing: Manually adjustable while valve is under pressure.
 4. Shafts:
 - a. Rigidly connected to the ball by a positive means.
 - 1) Design connection to transmit torque equivalent to at least 75 percent of the torsional strength of the shaft.
 5. Handles: Stainless steel latch lock handle with vinyl grip and stainless-steel nut designed to open and close the valve under operating conditions.
 6. Temperature limits: Suitable for operation between minus 20 and 350 degrees Fahrenheit.
- C. Materials:
1. Valves in copper lines: Bronze body.
 2. Valves in steel and ductile iron piping: Ductile iron or cast steel body.
 3. Valves in stainless steel piping: Stainless steel body, material type to match piping material as specified in Section 15052 Common Work Results for General Process Piping.
 4. Ball: Type 304 or 316 stainless steel, Type 316 in digester gas applications.
 5. Seats: PTFE.
 6. Stem seals: PTFE or Viton.
 7. Bearings: Self-lubricated, corrosion resistant material that will not contaminate potable water.
 8. Valves for combustible fluid applications (digester gas, natural gas, fuel oil, etc.) must be of fire safe design.

2.02 PLASTIC BODY BALL VALVES

- A. Manufacturers: One of the following or equal:

1. Asahi America.
 2. Chemtrol Division, NIBCO, Inc.
 3. Plast-O-Matic Valves, 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:
1. Body: Polyvinyl chloride (PVC).
 2. Ball: Polyvinyl chloride (PVC).
 3. Seats: PTFE (Teflon).
 4. O-rings: FKM (Viton).

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."

END OF SECTION

SECTION 15114

CHECK VALVES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Center guide (silent).
 - 2. Plastic ball check valves.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the CONTRACTOR's responsibility for scheduling and coordinating the work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR's work.

1.02 REFERENCES

- A. American Water Works Association (AWWA):
 - 1. C508 - Standard for Swing-Check Valves for Waterworks Service 2-inch through 24-inch (50-mm through 600-mm) NPS.
- B. American Society of Mechanical Engineers (ASME):
 - 1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
- C. ASTM International (ASTM):
 - 1. A 126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
 - 2. A 313 - Standard Specification for Stainless Steel Spring Wire.
 - 3. B 582 - Standard Specification for Nickel-Chromium-Iron-Molybdenum-Copper Alloy Plate, Sheet, and Strip.
 - 4. B 584 - Standard Specification for Copper Alloy Sand Castings for General Applications.

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. Under pressures equal and less than 150 pounds per square inch gauge.

1.04 SUBMITTALS

- A. Submit the following information as specified in Division 1 and Section 15110 Common Work Results for Process Valves:
 - 1. Product data.
 - 2. Certificates:
 - a. General purpose AWWA check valves:
 - 1) Affidavit of compliance attesting valves provided comply with all provisions in accordance with AWWA C508.
 - 3. Operation and maintenance data.

PART 2 PRODUCTS

2.01 CENTER GUIDE (SILENT) CHECK VALVES

- A. Manufacturers: One of the following or equal:
 - 1. APCO, Model Number 600.
 - 2. Crispin, Series GC.
- B. Valve design:
 - 1. Center guided, spring-loaded plug.
 - 2. Replaceable seat and plug.
 - 3. Shaft guide bushing.
 - 4. Non-slam, silent shut-off.
 - 5. Flanged body.
- C. Materials:
 - 1. Body: Cast iron, ASTM A 126 Grade B.
 - 2. Plug and seat: Bronze, ASTM B 584 C83600.
 - 3. Spring: Stainless steel, ASTM A 313 Type 316.
 - 4. Shaft and bushing: Bronze, ASTM B 584 C83600.

2.02 PLASTIC BALL CHECK VALVES

- A. Manufacturers: One of the following or equal:
 - 1. Chemtrol Division of Nibco.
 - 2. R. G. Sloane Company, Inc.
- B. Valves: Ball type:
 - 1. Polyvinyl chloride.
 - 2. Double or single union-type end connections.
 - 3. Seals: EPDM.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install valves per manufacturer's instructions.

END OF SECTION

15114-3

SECTION 15114A
DUCKBILL FLANGED-END CHECK VALVES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Duckbill check valves.

1.02 SUBMITTALS

- A. Submit product literature that includes information on the performance and operation of the valve, materials of construction, dimensions and weights, elastomer characteristics, headloss and flow data, and pressure ratings.
- B. Certifications of reference standard compliance
- C. Upon request, provide shop drawings that clearly identify the valve dimensions.
- D. Upon request, manufacturer shall provide installation and reference lists for existing valves of similar size and type to the project scope.

1.03 QUALITY ASSURANCE

- A. Manufacturer shall have conducted independent hydraulic testing to determine headloss and jet velocity characteristics on valves ranging from 2" through 48". The testing must include multiple constructions (stiffness) within each size and must have been conducted for free discharge (discharge to atmosphere) and submerged conditions.
- B. Manufacturer shall have conducted an independent hydraulic test where multiple valves of the same size and construction (stiffness) were tested to validate the submitted headloss characteristics and to prove the repeatability of the manufacturing process to produce the same hydraulic characteristics.
- C. The bill slit of the duckbill valve must be at least 1.57 times the nominal pipe diameter.

PART 2 PRODUCTS

2.01 MATERIALS

<u>COMPONENT</u>	<u>MATERIAL</u>
Body	Ethylene propylene diene monomer rubber M-class (EPDM)
Retaining Ring	Stainless Steel

15114A-1

2.02 GENERAL

- A. Check Valves are to be all rubber and of the flow operated check type with a flanged end connection. The port area shall contour down to a duckbill which shall allow passage of flow in one direction while preventing reverse flow. The flange and flexible duckbill sleeve shall be one-piece rubber construction with nylon reinforcement. The bill portion shall be thinner and more flexible than the valve body and formed into a curve of 180°.
- B. The flange drilling shall conform to ANSI B16.1 Class 125/ANSI B16.5, Class 150 standards. The valve shall be furnished with galvanized or stainless-steel back-up rings for installation.
- C. Manufacturer must have available flow test data from an accredited hydraulics laboratory to confirm pressure drop data. Company name, plant location, valve size and serial number shall be bonded to the check valve.

2.03 FUNCTION

- A. When line pressure inside the valve exceeds the backpressure outside the valve, the line pressure forces the bill of the valve open, allowing flow to pass. When backpressure exceeds the line pressure, the bill of the valve is forced closed.

2.04 MANUFACTURER

- A. Valves shall be of the Series 35 as manufactured by Tideflex Technologies, or approved equal

PART 3 EXECUTION

3.01 INSTALLATION

- A. Valve shall be installed in accordance with manufacturer's written Installation and Operation Manual and approved submittals and as shown on the Contract Drawings.
- B. Valve shall be installed with the bill vertical.

END OF SECTION

SECTION 15116

PLUG VALVES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Non-lubricated.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the CONTRACTOR'S responsibility for scheduling and coordinating the Work of SUBCONTRACTORS, SUPPLIERS, and other individuals or entities performing or furnishing any of CONTRACTOR'S Work.
 - 3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 09960A - High-Performance Coatings: VOC Limit 250 Grams Per Liter.
 - b. Section 15110 - Common Work Results for Process Valves.

1.02 REFERENCES

- A. American Water Works Association (AWWA):
 - 1. C517 - Resilient-Seated Cast Iron Eccentric Plug Valves.
- B. ASTM International (ASTM):
 - 1. A 126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
 - 2. A 536 - Standard Specification for Ductile Iron Castings.

1.03 SUBMITTALS

- A. Shop drawings: Submit the following information as specified in Division 1 and Section 15110:
 - 1. Product data.
 - 2. Operation and maintenance data.

PART 2 PRODUCTS

2.01 NON-LUBRICATED PLUG VALVES

- A. Manufacturers: One of the following or equal:

1. DeZurik, "PEC."
 2. Clow Valve.
- B. Design:
1. Type: Non-lubricated eccentric type, in accordance with AWWA C517.
 2. Plug face: Resilient material which operates satisfactorily at a temperature of 180 degrees Fahrenheit continuous and 215 degrees Fahrenheit intermittent.
 3. Compression washer: Provide flat compression washer made of Teflon, or of a material having equal physical characteristics on valve stem between plug and bonnet.
 4. Stem seals: Provide stem seals serviceable without unbolting the valve bonnet assembly.
 5. Clearly mark valves to indicate their open and closed positions.
 6. Provide valves with ends as required by piping details indicated on the Drawings.
- C. Materials:
1. Body and plug: ASTM A 126, Class B, cast-iron, with plug face of EPDM material suitable for the intended service as specified under paragraph "Design" above.
 2. Body seats in valves 3 inch size and larger: Provide with overlay of not less than 90 percent nickel and minimum thickness of 1/8 inch on surfaces contacting the plug face.
 3. Stem bearing and bottom bearing: Type 316 stainless steel backed TFE bearings.
 4. Internal parts, except the body and plug: Type 316 stainless steel.
 5. Exposed nuts, bolts, and washers: Zinc plated. Exception: Exposed nuts, bolts, and washers for buried service: Stainless steel.

2.02 VALVE OPERATORS

- A. Furnish valves with an operating wrench or worm gear operator:
1. Equip valves 4 inch nominal size and smaller with a lever operator.
 2. Equip valves 6 inch nominal size and larger with a worm gear operator.

2.03 COATING

- A. Coat interior metal surfaces as specified in Section 15110.
- B. Coat exterior metal surfaces as specified in Section 09960A.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install valves as specified in Section 15110 and the manufacturer's instructions.
- B. Install valves so that in the closed position the pressure in the pipeline applies a seating head on the valves.
- C. Install valves so that in the open position the plug is located in the top half of the valve body.

END OF SECTION

15116-3

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.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the CONTRACTOR'S responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR'S Work.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
 - a. Division 2 - Site Construction.
 - b. Section 09960A - High-Performance Coatings.
 - c. Section 15052 - Common Work Results for General Process Piping.
 - d. Section 15057 - Fusion Bonded Epoxy Lining.

1.02 REFERENCES

- A. American Society of Mechanical Engineers (ASME):
 - 1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
- B. American Water Works Association (AWWA):
 - 1. C104 - Standard for Cement-Mortar Lining for Ductile-Iron Pipe and Fittings.
 - 2. C105 - Polyethylene Encasement for Ductile-Iron Pipe Systems.
 - 3. C110 - Standard for Ductile-Iron and Gray-Iron Fittings.
 - 4. C111 - Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
 - 5. C115 - Flanged Ductile Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.
 - 6. C150 - Standard for Thickness Design of Ductile-Iron Pipe.
 - 7. C151 - Standard for Ductile-Iron Pipe, Centrifugally Cast.
 - 8. C153 - Standard for Ductile-Iron Compact Fittings for Water Service.
 - 9. C600 - Installation of Ductile Iron Water Mains and Their Appurtenances.
 - 10. C606 - Standard for Grooved and Shouldered Joints.
- C. American Welding Society (AWS):

1. D11.2 - Guide for Welding Iron Castings.
- D. ASTM International (ASTM):
 1. A 47 - Standard Specifications for Ferritic Malleable Iron Castings.
 2. A 183 - Standard Specifications for Carbon Steel Track Bolts and Nuts.
 3. A 536 - Standard Specifications for Ductile Iron Castings.
 4. C 283 - Standard Test Methods for Resistance of Porcelain Enameled Utensils to Boiling Acid.
 5. D 792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
- E. Ductile Iron Pipe Research Association (DIPRA):
 1. Thrust Restraint Design Manual.
- 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 Process 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 the criteria presented in the DIPRA Thrust Restraint Design Manual.
 - e. Safety factor: 1.5 (for thrust restraint calculations only).

1.04 SUBMITTALS

- A. Product data: Photographs, drawings, and descriptions of fittings, gaskets, couplings, grooving of pipe and fittings, pipe linings, and coatings.

- B. Shop drawings:
 - 1. Detailed layout drawings showing alignment of pipes, location of valves, fittings, and appurtenances, types of joints, connections to structures, and thrust restraint system layouts.
 - 2. Thrust restraint systems: Calculations and layout for restrained joint thrust restraint systems.
- C. Design calculations:
 - 1. Calculations for thrust restraint system design.
- D. Test reports:
 - 1. Submit Coating Manufacturer's Technical Representative's reports.

1.05 QUALITY ASSURANCE

- A. Qualifications:
 - 1. Lining manufacturers: For piping specified to receive glass or epoxy lining, use only a lining manufacturer having a minimum of 5 years' experience supplying this type of product to the wastewater and water industry.
- B. 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 piping and associated fittings for shipment to prevent damage to coatings and linings.
- B. Carefully handle piping and associated fittings during loading, unloading, and installation.
 - 1. Do not drop piping material from cars or trucks.
 - 2. Lower piping by mechanical means.
 - 3. Do not drop or pound pipe to fit grade.
- C. Protect gaskets and polyethylene encasement from long-term exposure to sunlight.
- D. 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. Ductile iron piping:

1. Typical type:
 - a. In accordance with AWWA C150 and AWWA C151.
 - b. Pressure class or special thickness class as indicated in the Piping Schedule provided in Section 15052 Common Work Results for General Process Piping.
 2. Type with screw-on flanges:
 - a. In accordance with AWWA C115 with minimum special thickness Class 53 wall thickness as required for screw-on flanges.
 - b. Special thickness class as indicated in the Piping Schedule as specified in Section 15052 Common Work Results for General Process Piping.
 3. Type with grooved couplings:
 - a. Special thickness class as indicated in the Piping Schedule as specified in Section 15052 Common Work Results for General Process Piping.
- B. Joints:
1. Flanged joints:
 - a. Screw-on flanges: Comply with the diameter, thickness, drilling, and other characteristics in accordance with ASME B16.1. In addition, comply with the following requirements:
 - 1) Ductile iron.
 - 2) Long hub, threaded, and specially designed for ductile iron pipe.
 - 3) After attaching to pipe, machine flange face to make pipe end and flange even and perpendicular to the axis of the pipe.
 - b. Bolt holes on flanges: 2-holed and aligned at both ends of pipe.
 - c. Cap screw or stud bolt holes: Tapped.
 - d. Bolts and nuts: As specified in Section 15052 Common Work Results for General Process Piping.
 - e. Gaskets: Standard styrene butadiene copolymer (SBR) unless specified otherwise in Section 15052 Common Work Results for General Process Piping.
 2. Push-on rubber gasket joints: In accordance with AWWA C111.
 3. Integrally restrained push-on joints:
 - a. Application:
 - 1) Where designation restrained push-on is specified in the Piping Schedule provided in Section 15052 Common Work Results for General Process Piping, supply a restrained push-on joint piping system, which includes restrained push-on joints where necessary based upon thrust calculations.
 - 2) Standard push-on rubber gasket joints as specified above can be used where thrust calculations demonstrate restraint is not required.
 - b. Design:
 - 1) Restrained push-on joints of the configuration which utilizes a gripping or friction force for restraint will not be acceptable.
 - 2) Suitable for the following working pressures:
 - a) For 4 through 24-inch pipe: 350 pounds per square inch gauge.
 - b) For 30 through 54-inch pipe: 250 pounds per square inch gauge.
 - c. Manufacturers: One of the following or equal:
 - 1) United States Pipe and Foundry Company, TR Flex.
 - 2) Pacific States Cast Iron Pipe Company, Thrust Lock.

- 3) American Cast Iron Pipe Company, Flex Ring or Lok-Ring.
- 4) Griffin Pipe Products Co., Snap-Lok.
- d. Limit buried joints to half the manufacturer's published allowable angular joint deflection for purposes of pipeline alignment and elimination of fittings.

C. 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 Process Piping.
3. Plain end-to-flanged joint connectors using setscrews are not acceptable.

D. Pipe linings and coatings:

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.
2. Asphaltic seal coat:
 - a. Apply over cement mortar linings and to outside surface of pipes that will not receive another coating. Apply in accordance with AWWA C151.
3. Elastomeric polyurethane (100 percent solids) lining:
 - a. As specified in Section 09960A High-Performance Coatings.
4. Ceramic epoxy lining:
 - a. Manufacturers: One of the following or equal:
 - 1) PROTECTO 401.
 - 2) SP-2000W.
 - b. Material: Amine cured novalac epoxy containing at least 20 percent by volume of ceramic quartz pigment.
 - c. Minimum dry film thickness (DFT): 40 mills.
 - d. Application:
 - 1) The lining shall only be applied by a manufacturer-authorized representative with no less than 5 years of experience in applying the specified material.
 - 2) The application of the lining shall be preformed in accordance with manufacturer's published specifications.
 - 3) Pipe and fittings shall be delivered to application facility with no interior lining.
 - 4) Interior of pipe shall be abrasive blasted per manufacturer's specifications.
 - e. Coverage:
 - 1) Gasket and spigot ends-on joints: Provide 6 mills minimum and 10 mills maximum coverage using joint compound as specified by the manufacturer for the gasket area and spigot ends.
 - 2) Mechanical joints: Extend lining from spigot end to edge of gauging ring.
 - 3) Number of coats: As recommended by the lining manufacturer.
 - f. Source quality control:

- 1) Test pipe and fitting lining with a magnetic film thickness gauge. Perform testing in accordance with the method outlined in SSPC PA 2 Film Thickness Rating.
 - 2) Test lining integrity of pipes using a holiday detection testing instrument set at the voltage as specified by the coating manufacturer:
 - a) Repair all holidays with joint compound in accordance with the recommendations of the coating manufacturer, and re-test.
 - 3) Discard piping or reline piping when pinholes or discontinuities are found.
5. Fusion bonded epoxy lining and coating for fittings only:
- a. As specified in Section 15057 Fusion Bonded Epoxy Lining.

2.02 POLYETHYLENE ENCASEMENT

- A. 2 layers of linear low-density polyethylene (LLDPE) film, minimum thickness of 8 mils in accordance with AWWA C105, or
- B. Single layer of high-density, cross-laminated polyethylene (HDCLPE) film, minimum thickness of 4 mils in accordance with 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 Process Piping.
 2. For underground piping, the trenching, backfill, and compaction: As specified in Division 2 Site Construction.
- B. Polyethylene Encasement:
 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.
- C. Joints:
 1. Install types of joints as specified in the piping schedule provided in Section 15052 Common Work Results for General Process 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.
- D. Tapping ductile iron pipe:
 1. Direct tapping of ductile iron pipe may be performed but is limited to the following conditions:
 - a. Maximum allowable tap diameter by pipe diameter and pressure class:

Pipe Size (inches)	Pressure Class				
	150	200	250	300	350
	Maximum Allowable Direct Tap Size (inches)				
3	-	-	-	-	3/4
4	-	-	-	-	3/4
6	-	-	-	-	1
8	-	-	-	-	1
10	-	-	-	-	1
12	-	-	-	-	1-1/4
14	-	-	1-1/4	1-1/2	1-1/2
16	-	-	1-1/2	2	2
18	-	-	2	2	2
20	-	-	2	2	2
24	-	2	2	2	2

- b. The maximum allowable tap diameter for pipelines greater than 24 inches is 2 inches.
- c. Two layers of 3-mil thread sealant are required to minimize the torque required to effect a watertight connection.

3.02 FIELD QUALITY CONTROL

- A. Testing ductile iron piping:
 - 1. Test as specified in Section 15052 Common Work Results for General Process Piping.
 - 2. Do not test sections longer than 1/2 mile in total pipe length.
- B. Repair damaged cement mortar lining to match quality, thickness, and bonding of original lining in accordance with AWWA C104.
 - 1. When lining cannot be repaired or repairs are defective, replace defective piping with undamaged piping.
- C. Verify that interior surfaces of glass lined pipe and fittings have continuous coverage:
 - 1. Verify with low voltage wet sponge holiday detector in accordance with NACE SP0188.
 - 2. Discard glass lined ductile iron piping and fittings with voids or casting anomalies that represent more than 0.01 percent of the total glassed surface.

- a. No more than 2 pinholes per fitting or an average of 5 or less pinholes per 20 feet of pipe.
3. Discard lined piping and fittings found to have pinholes, crazing, or fish scales, which expose the metal substrate.

END OF SECTION

SECTION 15247
POLYVINYL CHLORIDE (PVC) GRAVITY PIPE

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Gravity pipe and fittings in accordance with ASTM D3034 and ASTM F679 standards.
- B. Related sections:
 - 1. Section 01330 - Submittal Procedures.
 - 2. Section 15052 - General Requirements for Piping.
 - 3. Section 15956 - Piping System Testing.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. C923 - Standard Specification for Resilient Connectors between Reinforced Concrete Manhole Structures, Pipes, and Laterals.
 - 2. D1784 - Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
 - 3. D2321 - Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications.
 - 4. D3034 - Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
 - 5. D3212 - Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.
 - 6. F477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
 - 7. F679 - Standard Specification for Poly(Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings.

1.03 ABBREVIATIONS

- A. PVC: Polyvinyl chloride.
- B. SDR: Standard dimension ratio; the outside diameter divided by the pipe wall thickness.

1.04 SUBMITTALS

- A. Submit as specified in Section 01330 Submittal Procedures.
- B. Product data: As specified in Section 15052 General Requirements for Piping.

1.05 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 PIPE

- A. Extruding and molding material: Virgin material containing no scrap, regrind, or rework material except where permitted in the referenced standards.
- B. PVC compound: Cell classification 12454-C in accordance with ASTM D1784.
- C. Stabilizers, antioxidants, lubricants, colorants, and other additives and fillers not to exceed 10 parts by weight per 100 of PVC resin in the compound.
- D. Pipe less than or equal to 15-inch diameter:
 - 1. In accordance with ASTM D3034.
 - 2. Wall thickness SDR 26 or as specified in the Piping Schedule in Section 15052 General Requirements for Piping.
 - 3. Joints: Push-on in accordance with ASTM D3212.
 - a. Integral bell.
 - b. Factory installed gaskets meeting the requirements in accordance with ASTM F477.
- E. Pipe greater than or equal to 18-inch diameter:
 - 1. In accordance with ASTM F679.
 - 2. Minimum pipe stiffness: PS115 in accordance with Table 1 in ASTM F679.
 - 3. Joints: Push-on in accordance with ASTM D3212.
 - a. Integral bell.
 - b. Factory installed gaskets meeting the requirements in accordance with ASTM F477.
 - 4. Bell:
 - a. Fabricated from pipe sections.
 - b. Bell wall thickness equivalent to pipe wall thickness.
 - 5. Gasket ring: Locked into the bell.
 - 6. Spigot end of the pipe: Marked by the manufacturer to identify the final in-place position of the spigot in the bell.

2.02 FITTINGS

- A. Same material as the pipe.
- B. Minimum wall thickness: Same as the minimum wall thickness of the equivalent size pipe as specified in Table 1 of ASTM F679.

- C. Supplied by the pipe manufacturer.
- D. Factory molded with joints and gaskets equal to those of the pipe.
- E. Gasket:
 - 1. In accordance with ASTM F477.
 - 2. Manhole adapter gasket: Stainless steel clamp with gasket or similar device to seal the penetration.
- F. Flexible gaskets for precast bases with a flexible pipe connection:
 - 1. In accordance with ASTM C923.
 - 2. Manufacturer: The following or approved equal:
 - a. Press-Seal Gasket Corporation: PSX.
 - b. A-Lok Premium.
- G. Waterstop grouting rings:
 - 1. Manufacturer: The following or approved equal:
 - a. NPC.
 - b. Press-Seal Gasket Corporation.

2.03 SOURCE QUALITY CONTROL

- A. Mark pipe and fittings in accordance with ASTM D3034 and ASTM F679 as appropriate.
- B. Mark the production control code on pipe and fittings.

PART 3 EXECUTION

3.01 INSTALLATION

- A. General:
 - 1. Install piping in accordance with ASTM D2321 and manufacturer's published installation instructions.
 - 2. Provide plugs or caps for stubs and branch pipes left unconnected to laterals.
 - 3. Lubricate and assemble joints in accordance with the pipe manufacturer's published instructions.
- B. Connections to manholes:
 - 1. Make connections to manholes with a manhole gasket that prevents infiltration and exfiltration through the penetrations using 1 of the following methods:
 - a. Precast bases with a flexible pipe connection:
 - 1) Pipe connectors shall be cast into the base.
 - a) Pipe openings shall contain flexible gaskets.
 - 2) Follow manufacturer's recommendation for lubrication to prevent damage to the gasket during pipe insertion.
 - 3) When PSX gaskets are used, the take-up screws for the gasket clamps shall be positioned a minimum of 90 degrees apart.
 - 4) Install and grout in place per manufacturer's instructions.

- b. Cast in place or precast bases using grouting rings:
 - 1) Provide opening for connection large enough to allow subsequent grouting around the grouting ring.
 - 2) Grout around the pipe penetration manhole gasket and seal the opening.

3.02 FIELD QUALITY CONTROL

- A. Test pipe as specified in Section 15052 General Requirements for Piping and Section 15956 Piping System Testing.
- B. Mandrel tests:
 - 1. Perform initial mandrel test:
 - a. After cleaning and completion of other tests.
 - b. After placement and compaction of backfill.
 - c. Before construction of pavement or surfacing.
 - d. Not sooner than 30 days after pipe installation.
 - e. Not later than 60 days after installation.
 - 2. Perform final verification mandrel test:
 - a. Not sooner than 30 days before the end of the warranty period.
 - b. Not later than 10 days before the end of the warranty period.
 - c. Consider the final verification mandrel test a warranty service, and include the costs related to final verification mandrel test in the Contract Price.
 - 3. Utilize a 9 rod mandrel with minimum length equal to NPS and diameter as follows:

Nominal Pipe Size (NPS)	Mandrel Dia (in) (SDR 35/PS46)	Mandrel Dia (in) (SDR 26/PS 115)
6	5.45	5.33
8	7.28	7.11
10	9.08	8.87
12	10.79	10.55
15	13.20	12.90
18	16.13	15.76
21	19.00	18.57
24	21.36	20.87
27	24.06	23.51
30	27.68	27.04

- 4. Test procedure: Pull the mandrel through the line under test by 1 person, by hand, with reasonable effort, without the aid of mechanical equipment.
- 5. Failing test: Where the mandrel test is not successful, remove and replace the section of piping with the obstruction; test the piping again, including visible leaks

test, pressure test with maximum leakage allowance, mandrel tests, and other specified tests:

- a. Correction of excessive deflection or obstructions by methods other than removal of the affected piping and replacement of the removed piping with new piping will not be accepted.

END OF SECTION

SECTION 15956

PIPING SYSTEM TESTING

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Test requirements for piping systems.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the CONTRACTOR'S responsibility for scheduling and coordinating the work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR'S Work.
 - 3. The following sections are related to the work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed work complies accurately with the Contract Documents.

1.02 TESTING REQUIREMENTS

- A. General requirements:
 - 1. Testing requirements are stipulated in Laws and Regulations.
 - 2. Requirements in Laws and Regulations supersede other requirements of Contract Documents, except where requirements of Contract Documents are more stringent, including higher test pressures, longer test times, and lower leakage allowances.
 - 3. Test plumbing piping in accordance with Laws and Regulations, the plumbing code, and UL requirements.
- 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. 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.
- D. 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.

- E. Test completion: Drain and leave piping clean after successful testing.
- F. Test water disposal: CONTRACTOR is responsible for properly disposing of test water.

1.03 SUBMITTALS

- A. Schedule and notification of tests:
 - 1. Submit a list of scheduled piping tests by noon of the working day preceding the date of the scheduled tests.
 - 2. Notification of readiness to test: Immediately before testing, notify ENGINEER in writing of readiness, not just intention, to test piping.
 - 3. Have personnel, materials, and equipment specified in place before submitting notification of readiness.

1.04 SEQUENCE

- A. Clean piping before pressure or leak tests.
- B. Underground pressure piping may be tested before or after backfilling when not indicated or specified otherwise.
- C. Backfill and compact trench, or provide blocking that prevents pipe movement before testing underground piping with a maximum leakage allowance.
- D. 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 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.
- B. General:
 - 1. Test connections, valves, blowoffs, and closure pieces with the piping.
 - 2. Do not use installed valves for shutoff when the specified test pressure exceeds the valve's maximum allowable seat differential pressure. Provide blinds or other means to isolate test sections.
 - 3. Do not include valves, equipment, or piping specialties in test sections if test pressure exceeds the valve, equipment, or piping specialty safe test pressure allowed by the item's manufacturer.
 - 4. During the performance of the tests, test pressure shall not vary more than plus or minus 5 pounds per square inch gauge with respect to the specified test pressure.

5. Select the limits of testing to sections of piping. Select sections that have the same piping material and test pressure.
 6. When test results indicate failure of selected sections, limit tests to piping:
 - a. Between valves.
 - b. Between a valve and the end of the piping.
 - c. Less than 500-feet long.
 7. Test piping for minimum 2 hours for visible leaks test and minimum 2 hours for the pressure test with maximum leakage allowance.
- C. Testing procedures:
1. Fill piping section under test slowly with water while venting air:
 - a. Use potable water for all potable waterlines and where noted on the Piping Schedule.
 2. Before pressurizing for the tests, retain water in piping under slight pressure for a water absorption period of minimum 24 hours.
 3. Raise pressure to the specified test pressure and inspect piping visually for leaks:
 - a. Consider visible leakage testing complete when no visible leaks are observed.
- D. Pressure test with maximum leakage allowance:
1. Leakage allowance is zero for piping systems using flanged, National Pipe Thread threaded and welded joints.
 2. Pressure test piping after completion of visible leaks test.
 3. For piping systems using joint designs other than flanged, threaded, or welded joints, accurately measure the makeup water necessary to maintain the pressure in the piping section under test during the pressure test period:
 - a. Consider the pressure test to be complete when makeup water added is less than the allowable leakage and no damage to piping and appurtenances has occurred.
 - b. Successful completion of the pressure test with maximum leakage allowance shall 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 inches gauge, at the lowest point of the test section, corrected for elevation of the pressure gauge.

x = The multiplication symbol.

END OF SECTION

SECTION 15958
MECHANICAL EQUIPMENT TESTING

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Testing of mechanical equipment and systems.
- B. Related sections: The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 1. It is the CONTRACTOR'S responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR'S Work.
 - 2. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
 - a. Division 1 - General Conditions.
 - b. Division 2 - Site Construction.
 - c. Section 15956 - Piping System Testing.
 - d. Division 16 - Electrical.
 - e. Division 17 - Instrumentation.

1.02 REFERENCES

- A. American National Standards Institute (ANSI):
 - 1. S1.4 Specification for Sound Level Meters.
- B. Hydraulic Institute (HI).

1.03 SUBMITTALS

- A. Schedule of factory tests and field tests as specified in Division 1 General Conditions and this Section.
- B. Test instrumentation calibration data.
- C. Start-up plan as specified in Division 1 General Conditions.
- D. Test plan specified in this Section.
- E. Test result reports.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 QUALITY CONTROL TESTING AND REPORTING

- A. Scheduling and notification:
 - 1. Witnessed source quality control tests: Schedule test date and notify ENGINEER at least 30 days prior to start of test.
 - 2. Field quality control tests: Schedule test date and notify ENGINEER at least 7 days prior to start of test.
- B. Testing levels:
 - 1. Test equipment based on test levels specified in the equipment section of this Project.
 - 2. Requirements for Test Levels 1 to 4 are defined below.
 - 3. Test levels apply for both Source (Factory) Quality Control Tests and Field Quality Control Tests as specified in the equipment sections of this Project.
 - 4. If testing is not specified in the equipment section, provide Level 1 testing.
 - 5. Requirements of Division 1 General Conditions apply to Test Levels.
- C. Witnessing: Source Quality Control Tests not witnessed unless specified otherwise in the equipment section or Division 1 General Conditions; Field Quality Control Tests shall be witnessed.
- D. Instrumentation: Provide necessary test instrumentation which has been calibrated within 1 year from date of test to recognized test standards traceable to the National Institute of Standards and Technology, Washington, D.C. or approved source. Properly calibrated field instrumentation permanently installed as a part of the Work may be utilized for Field Quality Control Tests.
- E. Temporary facilities and labor: Provide necessary fluids, utilities, temporary piping, temporary supports, temporary access platforms or access means and other temporary facilities and labor necessary to safely operate the equipment and accomplish the specified testing. With OWNER'S permission, some utilities may be provided by fully tested permanently installed utilities that are part of the Work.
- F. Test fluids:
 - 1. Factory tests: Use water or air as appropriate at ambient conditions unless specified otherwise in the equipment section.
 - 2. Field tests: Use specified process fluid at available conditions.
- G. Pressure testing: Hydrostatically pressure test pressure containing parts in the factory at the appropriate standard or code required level above the equipment component specified design pressure or operating pressure, whichever is higher. Submit pressure test reports before shipping.
- H. 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. Improved (lower error tolerance) accuracies specified elsewhere prevail over this general requirement.
 2. Do not adjust results of tests for instrumentation accuracy. Measured values and values directly calculated from measured values shall be the basis for comparing actual equipment performance to specified requirements.
- I. Field testing:
1. Submit test plan as specified in Division 1 General Conditions and this Section. Indicate test start time and duration, equipment to be tested, other equipment involved or required; temporary facilities required, number and skill or trade of personnel involved; safety issues and planned safety contingencies; anticipated effect on OWNER'S existing equipment and other information relevant to the test. Provide locations of all instruments to be used for testing. Provide calibration records for all instrumentation.
 2. Perform general start-up and testing procedures as specified in Division 1 General Conditions.
 3. Prior to testing, verify equipment protective devices and safety devices have been installed, calibrated, and tested.
- J. Reports: Submit reports for source and field-testing. Submit Source Quality Control Test result reports before shipping equipment to the field. Report features:
1. Report results in a bound document in generally accepted engineering format with title page, written summary of results compared to specified requirements, and appropriate curves or plots of significant variables in English units.
 2. Include appendix with a copy of raw, unmodified test data sheets indicating test value, date and time of reading, and initials of person taking the data.
 3. Include appendix with sample calculations for adjustments to raw test data and for calculated results.
 4. Include appendix with the make, model, and last calibration date of instrumentation used for test measurements.
 5. Include in body of report a drawing or sketch of the test system layout showing location and orientation of the test instruments relative to the tested equipment features.

3.02 EQUIPMENT TESTING, GENERAL

- A. Tests for pumps, all levels of testing:
1. Test in accordance with applicable HI Standards in addition to the requirements in this and other Sections.
 2. Test tolerances: In accordance with appropriate HI Standards, except the following modified tolerances apply:
 - a. From 0 to plus 5 percent of head at the specified flows.
 - b. From 0 to plus 5 percent of flow at the rated design point head.
 - c. No negative tolerance for the efficiency at the specified flows.
 - d. 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.

- B. Tests for drivers: Test motors as specified in Division 16 Electrical. Test other drivers as specified in the driver equipment section.

3.03 REQUIREMENTS FOR VIBRATION TESTING

A. Definitions:

1. Peak-to-peak displacement: The root mean squared average of the peak-to-peak displacement multiplied by the square root of 2.
2. Peak velocity: The root mean squared average of the peak velocity multiplied by the square root of 2.

END OF SECTION

SECTION 16050
GENERAL ELECTRICAL WORK

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. Provide the electrical WORK, complete and operable, as indicated in accordance with the Contract Documents.
- B. The provisions of this Section shall apply to all Sections in Division 26, except as otherwise indicated by respective specification.
- C. Work included:
 - 1. The WORK of this Section is required for operation of electrically-driven equipment provided under Specifications in other Divisions.

1.02 RELATED WORK

- A. Section 01100 Summary of Requirements
- B. Section 01330 Submittal Procedures
- C. Section 01730 Operation and Maintenance Information
- D. Division 16 Electrical Specifications
 - 1. The CONTRACTOR'S attention is directed to the requirement for proper coordination of the WORK of this Section with the WORK of equipment Specifications, the WORK of instrumentation Sections.
 - 2. Concrete, excavation, backfill, and steel reinforcement required for encasement, installation, or construction of the WORK of the various Sections of Division 16 is included as a part of the WORK under the respective Sections, including duct banks, manholes, handholes, equipment housekeeping pads, and light pole bases.
- E. Division 17 Instrumentation Specifications

1.03 REGULATORY AGENCIES AND STANDARDS

- A. Regulatory Agencies: Installation, materials, equipment and workmanship shall conform to the latest provisions of the following agencies:
 - 1. CBC California Building Code
 - 2. CCR (TITLE 24 – PART 3) California Electrical Code
 - 3. NEC (NFPA 70) National Electrical Code: 2020 Edition
 - 4. OSHA Occupational Safety and Health Act
 - 5. Title 8, Subchapter 5, California Administrative Code Electrical Safety Orders
 - 6. UBC Uniform Building Code
- B. Electrical equipment shall be listed by and shall bear the label of Underwriters' Laboratories, Inc. (UL) or an independent testing laboratory acceptable to the local code enforcement agency having jurisdiction.
- C. Installation of electrical equipment and materials shall comply with OSHA Safety and Health Standards (29 CFR 1910 and 29 CFR 1926, as applicable), state building standards, and applicable local codes and regulations.
- D. Standards: Where referenced in these specifications or on the drawings, the publications and standards of the following organizations apply:
 - 1. AEIC Association of Edison Illuminating Companies

2. ANSI	American National Standards Institute
3. ASTM	American Society of Testing and Materials
4. ICEA	Insulated Cable Engineers Association
5. IEEE	Institute of Electrical and Electronics Engineers
6. NEMA 250	Enclosure for Electrical Equipment (1000 Volts Maximum)
7. NFPA	National Fire Protection Association
8. NETA	International Electrical Testing Association

E. Where the requirements of the specifications conflict with UL, NEMA, NFPA, or other applicable standards, the more stringent requirements shall govern.

1.04 SUBMITTALS

A. General

1. Furnish submittals in accordance with the requirements of Section 01330 – Submittal Procedures.
2. Custom-prepare Shop Drawings.
3. Drawings or data indicating "optional" or "as required" equipment will not be accepted.
4. Cross out options not proposed or delete from the Shop Drawings.

B. Shop Drawings

1. Shop drawings shall include the following:
 - a. Complete material lists stating manufacturer and brand name of each item or class of material.
 - b. Shop Drawings for grounding WORK not specifically indicated
 - c. Front, side, rear elevations, and top views with dimensional data
 - d. Location of conduit entrances and access plates
 - e. Component data
 - f. Connection diagrams, terminal numbers, internal wiring diagrams, conductor size, and cable numbers
 - g. Method of anchoring, seismic requirements, weight
 - h. Types of materials and finish
 - i. Nameplates
 - j. Temperature limitations, as applicable
 - k. Voltage requirement, phase, and current, as applicable
 - l. Front and rear access requirements
 - m. Test reports
 - n. Grounding requirements

C. Catalog Cuts

1. Submit catalog cuts or photocopies of applicable pages of bulletins or brochures for mass produced, non-custom manufactured material.
2. Stamp the catalog data sheets in order to indicate the Project name, applicable Specifications Section and Paragraph, model number, and options.

D. Materials and Equipment Schedules

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1. Within 30 Days of the commencement date in the Notice to Proceed, deliver to the ENGINEER a complete list of materials, equipment, apparatus, and fixtures that are proposed for use.
 2. Include in the list the type, size, name of manufacturers, catalog number, and such other information as required to identify the item.
- E. Include with each submittal a copy of this specification section, with addenda updates included, and all referenced and applicable sections included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the CONTRACTOR, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The ENGINEER shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the CONTRACTOR with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

1.05 FACILITY OPERATION AND MAINTENANCE MANUALS

A. General

1. Submit complete operation and maintenance manual in accordance with the requirements of Section 01730 – Operation and Maintenance Information.

1.06 As-Built Drawings

1. Prepare as-built drawings, including but not limited to showing invert and top elevations and routing of duct banks and exact location of concealed below-grade electrical installations, and color coding of each individual control conductor.
2. Maintain AS-BUILT drawings and update in conjunction with CONSTRUCTION progress of installation. AS-BUILT drawings shall be a full-sized set of drawings marked to reflect deviations, modifications and changes.
3. Furnish the drawings to the ENGINEER in accordance with the requirements of Section 01330 – Submittals Procedures.

1.07 IDENTIFICATION FOR ELECTRICAL SYSTEMS

A. Identification

1. Provide danger, caution, and warning signs and equipment identification markings in accordance with applicable federal, state, OSHA, and NEC requirements.

B. Local Disconnect Switches

1. Legibly mark each local disconnect switch for motors and equipment in order to indicate its purpose, unless the purpose is indicated by the location and arrangement.

C. Warning Signs

1. 600 Volts Nominal, or Less
 - a. Mark entrances to rooms and other guarded locations that contain live parts with conspicuous signs prohibiting unqualified persons from entering.

D. Isolating Switches

1. Provide isolating switches not interlocked with an approved circuit-interrupting device with a sign warning against opening them under load.

1.08 PERMANENT PUBLIC UTILITIES REQUIREMENTS

- A. No servicing utility interfaces, requirements, or fees.

1.09 PERMITS AND INSPECTION

- A. Obtain permits and pay inspection fees according to the General Conditions.

1.10 AREA DESIGNATIONS

- A. General

1. Designations for raceway system enclosures shall comply with the requirements of Section 16110 – Electrical Raceway Systems.
2. Designations for electrical WORK specifically indicated in other Sections shall comply with the requirements of those Sections unless indicated otherwise.
3. Designations for other electrical WORK not included in the above Paragraphs shall be as follows:

AREA	NEMA ENCLOSURE CLASSIFICATION					
	1	3R	7	9	12	Notes
MCC-06-01		X				

4. Designations for electrical WORK not included in the above Paragraphs shall be NEMA 4X.
5. Installations in hazardous locations shall conform strictly to the requirements of the indicated Class, Group, and Division.

- B. Material Requirements

1. Provide sealing fittings in chlorine and hydrofluosilicic (HFS) acid areas.
2. Construct NEMA 4X enclosures of Type 304 or 316 stainless steel, except in chlorine and HFS areas where non-metallic enclosures shall be provided.
3. Do not coat NEMA 4X enclosures.
4. Construct NEMA 7 enclosures of cast aluminum where used with aluminum conduit, and of cast iron when used with galvanized steel conduit.
5. Do not coat NEMA 7 and 9 enclosures.
6. Construct NEMA 1, 3R, and 12 enclosures of steel, and prime and coat with ANSI 61 light grey paint.

1.11 TESTS

- A. The CONTRACTOR shall be responsible for factory and field tests indicated in Division 26, as required by the ENGINEER, and as required by other authorities having jurisdiction.
- B. Furnish necessary testing equipment.
- C. Pay the costs of the tests, including replacement parts and labor, due to damage resulting from damaged equipment or from testing and correction of a faulty installation.
- D. Reporting
1. Where test reporting is indicated, submit proof-of-design test reports for mass-produced equipment with the Shop Drawings.

2. Submit factory performance test reports for custom-manufactured equipment for approval prior to shipment.
 3. Submit field test reports for review prior to Substantial Completion.
- E. Remove and replace equipment or material that fails a test, or, if the ENGINEER approves, repair and retested for compliance.
- F. Corrections to equipment or materials with a factory warranty shall be as recommended by the manufacturer and shall be performed in a manner that does not void the warranty.

1.12 CONSTRUCTION SEQUENCING

A. General

1. Continuance of facility operation during the expansion process is critical, the CONTRACTOR shall coordinate the WORK to be provided in, on, or adjacent to existing equipment.
2. Submit a written sequencing request, including the sequence and duration of activities to be performed during plant shutdown. Schedule of WORK, shall be subject to OWNER and Engineer approval, to minimize required shutdown time.
3. Switching, safety tagging, and lock-out, as required for plant shutdown or to isolate existing equipment, shall be performed by the CONTRACTOR under the direction of OWNER.

B. Modifications

1. Perform modifications or alterations to existing electrical facilities as required to successfully install and integrate the proposed electrical equipment as indicated.
2. Perform modifications to existing equipment, panels, and cabinets in a professional manner.
3. Repair coatings to match existing.
4. The costs for modifications to existing electrical facilities that are required for a complete and operating system shall be included as part of the WORK.

C. Existing Utilities

1. Exercise extreme caution when digging trenches to not damage existing underground utilities.
2. The cost of repairs of damages caused during construction shall be included as a part of the WORK.

D. Field Verifications

1. Visit the Site before submitting a Bid to become better acquainted with the WORK of this Contract.
2. The lack of knowledge will not be accepted as justification for extra compensation to perform the WORK.
3. The CONTRACTOR shall be responsible for identifying available existing circuit breakers in lighting panels for the intended use as required.
4. The CONTRACTOR shall be responsible for field verifying the available space in substation switchboards to integrate new power circuit breakers.
5. The cost for the above verifications shall be included as part of the WORK.

E. Installation of Temporary Equipment

1. To facilitate the continuous operation of existing equipment, provide the temporary equipment as indicated.
2. Submit installation and connection details for review and acceptance by the ENGINEER.
3. Costs associated with these temporary installations shall be included as part of the WORK.

4. Temporary wiring and equipment shall remain the property of the CONTRACTOR unless indicated otherwise.

PART 2 - MATERIALS

2.01 GENERAL

- A. Provide equipment and materials that are new and are the products of experienced and reputable manufacturers in the industry.
- B. Provide equipment and materials listed by UL and bearing the UL label, where UL requirements apply.
- C. Furnish equipment and material products of the same manufacturer. Equipment and materials shall be of industrial grade standard of construction.
- D. Temperature Ratings of Equipment Terminations
 1. Provide terminations and lugs rated for use with 75-degree C conductors.
 2. Wire sizes in the Contract Documents are based on NEC ampacity tables using the 75-degree C ratings.
 3. Provide equipment and materials suitable for storage, installation and operation in an ambient of 0°C to 50°C up to an elevation of 3,300 feet above sea level, except where more stringent conditions are stated in individual equipment specifications.
- E. Furnish factory finished electrical equipment, wireways and panels with manufacturer's standard primer and enamel topcoats, unless stated otherwise in the individual equipment specifications.
 1. Provide 1 pint of the equipment manufacturer's touch-up paint per 500 square feet of painted surface for repair of damaged enamel topcoats.

2.02 ELECTRICAL IDENTIFICATION

- A. Nameplates
 1. Fabricate nameplates from white-letter, black-face laminated plastic engraving stock, such as **Formica Type ES-1** or equal.
 2. Securely fasten each nameplate, using fasteners constructed of brass, cadmium-plated steel, or stainless steel, and screwed into inserts or tapped holes as required.
 3. Provide engraved characters of the block style, with no characters smaller than 1/8-inch top to bottom.
 4. Provide nameplates for field mounted devices and instruments, such as pressure switches, limit switches, flow meters, etc. Identify the name of the device and its unique identifier:

Examples:	Pressure Switch	Limit Switch
	PS-1	LS-1

5. Where it is impractical to attach laminated nameplates to field devices, provide 19-gauge, 2-inch square brass tags with 1/4-inch black filled engraving. Provide Seton Standard Brass Valve tags or equivalent. Attach tags with No. 16 brass jack chain.
- B. Conductor and Equipment Identification
 1. Provide heat shrink sleeve markers, Brady Permasleeve or approved equal.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Provide materials and provisions required for a complete and operable system, even if not required explicitly by the Contract Documents.

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- B. Typical provisions include terminal lugs not furnished with vendor-supplied equipment, compression connectors for cables, splices, junction and terminal boxes, and control wiring required by vendor-furnished equipment to connect with other equipment indicated in the Contract Documents.
- C. The Drawings diagrammatically indicate the desired location and arrangement of outlets, conduit runs, equipment, and shall be used as closely as possible.
- D. Exact locations shall be determined by the CONTRACTOR in the field, based on the physical size and arrangement of equipment, finished elevations, and other obstructions.
- E. Conduits
 - 1. Where conduit development drawings or "home runs" are indicated, route the conduits in accordance with those requirements.
 - 2. Provide exposed or encased routings as indicated, except conceal conduit in finished areas unless indicated otherwise.
 - 3. Size conduits encased in a slab for conduit OD not to exceed 1/3 of the slab thickness, and lay out and space as to not impede concrete flow.
- F. Placement
 - 1. Install conduit and equipment as to avoid obstructions, to preserve headroom, and to keep openings and passageways clear.
 - 2. Locate luminaires, switches, convenience outlets, and similar items within finished rooms as indicated.
 - 3. Where exact locations are not indicated, such locations will be determined by the ENGINEER.
 - 4. If equipment is installed without instruction and must be moved, the cost of moving shall be included as part of the WORK.
 - 5. Adjust luminaire locations in order to avoid obstructions and to minimize shadows.
- G. Circuits
 - 1. Wherever conduits and wiring for lighting and receptacles are not indicated, it shall be the CONTRACTOR'S responsibility to provide lighting and receptacle-related conduits and wiring as required, based on the actual installed fixture layout and the circuit designations as indicated.
 - 2. Provide No. 12 AWG minimum wiring, and 3/4-inch minimum conduits (exposed) and one-inch minimum conduits (encased).
 - 3. Where circuits are combined in the same raceway, de-rate conductor ampacities in accordance with NEC requirements.
- H. Workmanship
 - 1. Install materials and equipment in strict accordance with the printed recommendations of the manufacturer, and using workers skilled in the WORK.
 - 2. Coordinate installation in the field with other trades in order to avoid interferences.
- I. Protection of Equipment and Materials
 - 1. Fully protect materials and equipment against damage from any cause.
 - 2. Cover materials and equipment, both in storage and during construction, in such a manner that no finished surfaces will be damaged, marred, or splattered with water, foam, plaster, or paint.
 - 3. Keep moving parts clean and dry.

- 4. Replace or refinish damaged materials or equipment, including faceplates of panels and switchboard sections, as part of the WORK.
- J. Provide starters shall be in accordance with the requirements of Section 16480 – Low Voltage Motor Control Center for starters in MCC'S.

3.02 CORE DRILLING

- A. Perform core drilling as required for the installation of raceways through concrete walls and floors.
- B. Base the locations of floor penetrations, as may be required, on field conditions.
- C. Verify exact core drilling locations based on equipment actually furnished as well as exact field placement.
- D. To the extent possible, identify the existence and locations of encased raceways and other piping in existing walls and floors with the OWNER prior to any core drilling activities.
- E. Repair damage to encased conduits, wiring, and piping as part of the WORK.

3.03 CONCRETE HOUSEKEEPING PADS

- A. Provide concrete housekeeping pads for indoor floor-standing electrical equipment.
- B. Extend housekeeping pads for equipment, including future units, 4 inches above the surrounding finished floor or grade, and one inch larger in both dimensions than the equipment, unless otherwise indicated.
- C. Provide concrete housekeeping curbs for conduit stub-ups in indoor locations that are not concealed by equipment enclosures.
- D. Extend housekeeping curbs to 3 inches above the finished floor or grade.

3.04 EQUIPMENT ANCHORING AND RESTRAINTS

- A. Floor-supported, wall, or ceiling-hung equipment and raceways shall be anchored in place by methods that will meet seismic requirements in the area where the Project is located.
- B. Refer to Section 16070 for support and anchorage requirements.
- C. Provide fabricated steel support pedestals for wall-mounted panels that weigh more than 500 pounds or that are within 18 inches of the floor.
- D. If the supported equipment is a panel or cabinet enclosed within removable side plates, match supported equipment in physical appearance and dimensions.
- E. Provide leveling channels anchored to the concrete pad for MCC's, switchgear and other electrical equipment mounted on housekeeping pads.
- F. Manufacturer's Recommendations
 - 1. Anchoring methods and leveling criteria in the printed recommendations of the equipment manufacturers are a part of the WORK of this Contract.
 - 2. Submit such recommendations as Shop Drawings as indicated.

3.05 EQUIPMENT IDENTIFICATION

- A. Provide nameplates for panelboards, control and instrumentation panels, starters, switches, and pushbutton stations.
- B. In addition to nameplates, equip control devices with standard collar-type legend plates.
- C. Identify control devices within enclosures as indicated and similar to the subparagraph above.
- D. Provide suitable inscribed finish plates for toggle switches that control loads out of sight of switches and for multi-switch locations of more than 2 switches.
- E. Use equipment names and tag numbers, where indicated, on nameplates.

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- F. Provide typewritten circuit directories for panelboards, that accurately reflect the outlets connected to each circuit.
- G. Terminal Blocks
 - 1. Label termination points on terminal blocks by identifiers on the blocks.
 - 2. Provide identifiers that have been preprinted by the terminal manufacturer or custom-printed.
 - 3. Hand-lettered markers will not be accepted.
- H. Provide arc-flash labels for all distribution equipment, stand-alone disconnects, starters, and VFDs. Fill in all values as required by NFPA 70E, and as calculated as part of the Protective Device Study. Verify that all settings as prescribed by the approved Protective Device Study have been implemented in the field.

3.06 CLEANING

- A. Before final acceptance, thoroughly clean the electrical WORK of cement, plaster, and other materials.
- B. Remove temporary tags, markings, stickers, and the like.
- C. Remove oil and grease spots with a non-flammable cleaning solvent by carefully wiping and scraping cracks and corners.
- D. Apply touch-up paint to scratches on panels and cabinets.
- E. Vacuum clean electrical cabinets and enclosures. Do not use compressed air to clean cabinets.
- F. Clean luminaires inside and out. Replace failed lamps.
- G. Properly dispose cleaning debris and refuse off-site.

END OF SECTION

SECTION 16070
SEISMIC RESTRAINTS AND SUPPORTS

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. The CONTRACTOR shall provide seismic restraint devices for electrical systems, complete and operable, in accordance with the Contract Documents.

1.02 SUBMITTALS

- A. Submittals shall be in accordance with Section 01330 – Submittal Procedures and Section 16050 – General Electrical Work.
- B. Submit seismic anchoring calculations with equipment and raceway submittals. Calculations and determination of anchor types shall be performed and stamped by a licensed structural engineer registered in the State of California. Engineer shall either be employed by the equipment manufacturer or the equipment manufacturer shall hire an independent consultant to perform these services.
- C. Submit equipment anchoring methods. Include anchoring locations, anchor types and minimum anchor embedment depths.
- D. Submit catalog cuts and material list for each anchor type.
- E. Submit recommended torque values for bolting.

PART 2 - MATERIALS

2.01 SEISMIC ANCHORING AND RESTRAINTS

- A. Equipment Anchors:
1. Securely anchor electrical equipment. Anchoring shall have the capability of withstanding seismic forces per ASCE 7-05, Minimum Design Loads for Buildings and Other Structures, Chapter 13, with SDS = 0.686, IP = 1.5, RP = 2.5, and ap = 1.0.
- B. Raceway Supports:
1. Seismically support raceways (conduit, cable tray, busway, etc.) 2.5 inches inside diameter and larger and suspended 12 inches or more from the top of the raceway to the bottom of the support for the hanger. Raceway supports shall have the capability of withstanding seismic forces per ASCE 7-05, Minimum Design Loads for Buildings and Other Structures, Chapter 13, with SDS = 0.686, IP = 1.5, RP = 2.5, and ap = 1.0.
 2. Seismically supported raceway systems shall currently be pre-approved by the California Office of Statewide Health Planning and Development.

2.02 MOUNTING HARDWARE

- A. Miscellaneous Hardware
1. Provide nuts, bolts, and washers constructed of stainless steel.
 - a. Materials
 - All Areas: Anchor bolts and screws shall be Type 316 ASTM A276 stainless steel. Nuts shall be hex Type 316 stainless steel, ASTM A194, Grade 8M, or ASTM F594, Type 316 stainless steel.
 2. Provide threaded rods for trapeze supports constructed from continuous threaded galvanized steel, 3/8-inch diameter minimum.
 - a. Materials

- All Areas: ASTM A276, Type 304 stainless steel.

B. Struts

1. Construct struts for mounting of conduits and equipment of 304 stainless steel.
2. Where contact with concrete or dissimilar metals may cause galvanic corrosion, use suitable non-metallic insulators in order to prevent such corrosion.
3. Aluminum strut for free-standing support frames is not permitted.
4. Strut Manufacturer, or Equal: **Unistrut; B-Line**

C. End Caps

1. Provide plastic protective end caps for all exposed strut ends.
2. End Caps Manufacturer, or Equal: **Unistrut, Model P2860**

D. Anchors

1. Provide stainless steel expansion anchors for attaching equipment to concrete walls, floors, and ceilings.
2. Wood plugs will not be accepted.
3. Anchor Manufacturer, or Equal: "**Power-Bolt**" or "**Power-Stud**" as manufactured by **Power Fasteners, Inc.**; similar by **Star**.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. The CONTRACTOR shall provide and install equipment anchors and raceway supports in accordance with the final shop drawings and manufacturer's recommendations. Properly torque all bolts to the recommended values.

END OF SECTION

SECTION 16110
ELECTRICAL RACEWAY SYSTEMS

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. Provide electrical raceway systems, complete and in place, as indicated in accordance with the Contract Documents.
- B. In the event that individual equipment loads provided are larger than indicated in the Contract Documents, revise raceways, conductors, starters, overload elements, and branch circuit protectors as necessary in order to control and protect the increased connected load in conformance to NEC requirements as part of the WORK.

1.02 SUBMITTALS

- A. Furnish submittals in accordance with Section 01330 – Submittal Procedures, and Section 16050 – General Electrical Work.
- B. Shop Drawings
 - 1. Submit complete catalog cuts of raceways, fittings, boxes, supports, and mounting hardware, marked where applicable to show proposed materials and finishes.
 - 2. As-Built Drawings
 - a. Prepare as-built drawings of encased concealed and exposed raceways, ducts, raceways, junction boxes, pull boxes, and electrical and instrumentation equipment.
 - b. Furnish the drawings to the ENGINEER in accordance with the requirements of Section 01330 – Submittal Procedures.

PART 2 - PRODUCTS

2.01 GENERAL

- A. Pull and junction boxes, fittings, and other indicated enclosures that are dedicated to the raceway system shall comply with the requirements of this Section.

2.02 CONDUIT

- A. Galvanized Rigid Steel (GRS) Conduit
 - 1. Provide rigid steel conduit manufactured from mild steel, hot-dip galvanized inside and out.
 - 2. Provide rigid steel conduit manufactured in accordance with NEMA C80.1 – Electrical Rigid Steel Conduit, and UL-6 – Electrical Rigid Metal Conduit - Steel.
- B. PVC Rigid Non-Metallic Conduit
 - 1. Provide rigid non-metallic conduit manufactured from Schedule 40 PVC, as indicated, and sunlight-resistant.
 - 2. Provide rigid non-metallic conduit manufactured in accordance with NEMA TC-2 - Electrical Plastic Tubing and Conduit, and UL-651 - Standard for Rigid Non-metallic Conduit.
- C. Rigid PVC-Coated Galvanized Steel (GRS/PVC) Conduit
 - 1. The conduit shall meet the requirements for GRS conduit as indicated above.
 - 2. Bond a PVC coating to the outer surface of the galvanized conduit.
 - 3. Ensure that the bond between the coating and the conduit surface is greater than the tensile strength of the coating.
 - 4. Provide the inside surfaces and threads of the conduit with a 2-mil urethane coating.

5. Provide a PVC coating thickness not less than 40 mils.
6. The PVC-coated GRS shall be manufactured in accordance with the following standards:
 - a. UL-6
 - b. ANSI C80.1
 - c. NEMA RN1 - PVC Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit

D. Liquid-Tight Flexible Conduit

1. Provide liquid-tight flexible conduit constructed of a flexible galvanized metal core with a sunlight-resistant thermoplastic outer jacket.
2. Provide liquid-tight flexible conduit manufactured in accordance with the requirements of UL-360 - Steel Conduits, Liquid-Tight Flexible.

E. Electrical Metallic Tubing (EMT) or Intermediate conduit (IMC) will not be accepted.

2.03 FITTINGS AND BOXES

A. General

1. For use with metallic conduit, provide cast and malleable iron fittings of the threaded type with 5 full threads.
2. Fittings and Boxes
 - a. Provide fittings and boxes with neoprene gaskets and non-magnetic stainless steel screws.
 - b. Attach covers by means of holes tapped into the body of the fitting.
 - c. Covers for fittings attached by means of clips or clamps will not be accepted.
 - d. Provide surface-mounted switches and receptacles shall be housed in FD-type weatherproof conduit fittings. Bell type are not permitted.
3. Provide boxes larger than standard cast or malleable types manufactured of Type 304 or Type 316 stainless steel, NEMA 4X.
4. Terminations
 - a. In outdoor areas, terminate conduit in rain-tight hubs.
 - b. Manufacturer, or Equal
 - **Myers**
 - **O.Z. Gedney**
 - **Appleton**
 - c. In other than outdoor areas, provide sealed locknuts and bushings.
5. Hazardous Locations
 - a. In hazardous locations, provide conduit, fittings, and boxes suitable for the indicated Class and Division.
 - b. Provide conduits terminated in NEMA 7 boxes with a male bushing, inside the box.
 - c. Manufacturer, or Equal
 - **Adalet Type PEM**

B. Malleable Iron Fittings and Boxes

1. For use with galvanized steel conduit, provide fittings and boxes constructed of malleable iron or gray-iron alloy with zinc plating.

2. Manufacturer, or Equal
 - a. **Crouse-Hinds (EATON) Form 5**
 - b. Equivalent by **O.Z. Gedney**
 - c. Equivalent by **Appleton**
- C. PVC Fittings and Boxes
 1. For use with rigid non-metallic conduit, provide fittings manufactured of solvent-welded PVC.
 2. Provide boxes manufactured of PVC or fiberglass reinforced polyester (FRP).
 3. Manufacturer, or Equal
 - a. **Hoffman**
 - b. **Crouse-Hinds (EATON)**
 4. Provide welding solvent as required for the installation of non-metallic conduit and fittings.
- D. PVC-Coated GRS Fittings
 1. For use with PVC-coated GRS, provide PVC-coated coated that are the products of the same manufacturer as the conduit.
 2. Provide male and female threads and internal surfaces with a 2-mil urethane coating.
- E. Stainless Steel Boxes
 1. Provide stainless steel boxes with PVC-coated GRS conduit and where indicated.
 2. Provide NEMA 4X stainless steel boxes, constructed of Type 316 stainless steel.
 3. Provide stainless steel of a minimum of 14-gauge thickness, with a brushed finish.
 4. Door Hinges
 - a. Provide doors with full-length stainless steel piano hinges.
 - b. Non-hinged boxes will not be accepted.
 5. Manufacturer, or Equal
 - a. **Hoffman**
 - b. **Rittal**
- F. Sheet Steel Boxes
 1. Sheet steel boxes shall be galvanized steel outlet and switch boxes.
 2. Manufacturer, or Equal
 - a. **Raco**
 - b. **Steel City**
 - c. **Appleton Electric**

2.04 HAZARDOUS LOCATIONS

- A. Conform with NEC Articles 501 and 502 for areas identified as "Hazardous Areas".
- B. Provide threaded cast boxes and fittings for junction boxes and pull boxes in Class I and Class II areas. Unless otherwise indicated, boxes and fittings shall be UL listed for installation in Class I, Groups A, B, C, and D and Class II, Groups E, F, and G.
- C. Fixture hangers for pendant-mounted lighting fixtures shall conform to Class I, Division 1 and Class II Division 1 requirements.
- D. Provide conduit seals with sealing compound and fiber in Class I, Division I location within 18 inches of each conduit entering an enclosure containing electrical devices except for

hermetically sealed switches and receptacles. Provide a conduit seal for each conduit leaving the hazardous location.

- E. Flexible connections to motors and other vibrating equipment in Class I, Division I locations shall be made with flexible fittings approved for Class I locations.

2.05 WIREWAY

A. General

1. Provide wireway of the lay-in type and NEMA-rated for the area in which it is to be installed in accordance with the requirements of Section 16050 – General Electrical Work.
2. Separate power, control, signal and communications cables by grounded metallic dividers in wireways or run in separate wireways.

B. Fittings and Covers

1. Provide fittings and sections with non-magnetic stainless steel screws.
2. Attach covers by hinges and clamps to the bodies.
3. Covers attached by means of clips or screws will not be accepted.
4. Provide covers and bodies constructed of aluminum or minimum 14-gauge steel.

C. Grounding

1. Ground the steel and aluminum wireway bodies.
2. Provide steel dividers with steel wireways or aluminum dividers with aluminum wireways, and ground by means of an individual grounding conductor.
3. Non-metallic dividers will not be accepted.

D. Terminations

1. In indoor and outdoor areas, terminate conduit in rain-tight hubs as manufactured by Myers, O.Z. Gedney, or equal.
2. Manufacturer, or Equal
 - a. **Myers**
 - b. **O.Z. Gedney**

PART 3 - EXECUTION

3.01 GENERAL

- A. Run wiring in raceway unless indicated otherwise.
- B. Install raceways between equipment as indicated.
- C. Provide raceway systems that are electrically and mechanically complete before conductors are installed.
- D. Bends and Offsets
 1. Provide bends and offsets that are smooth and symmetrical, and accomplished with tools designed for this purpose.
 2. Provide factory elbows wherever possible.
- E. Routing
 1. Where raceway routings are indicated, follow those routings to the extent possible.

2. Where raceways are indicated but routing is not indicated, such as home runs or on conduit developments and schedules, raceway routing shall be the CONTRACTOR's choice and provided in strict accordance with the NEC as well as customary installation practice.
 3. Provide the raceway encased, exposed, concealed, or under-floor as indicated, except conceal conduit in finished areas unless specifically indicated otherwise.
 4. Adjust routings in order to avoid obstructions.
- F. Coordination
1. Coordinate between trades prior to installing the raceways.
 2. The lack of such coordination shall not be justification for extra compensation, and any costs for removal and re-installation to resolve conflicts shall be part of the Contract Price.
- G. Support wireways in accordance with the manufacturer's recommendations for the seismic requirements indicated in Section 16050 – General Electrical Work
- H. Install exposed raceways parallel or perpendicular to structural beams.
- I. Expansion Fittings
1. Install expansion fittings with external bonding jumpers wherever exposed raceways cross building expansion joints.
 2. Install expansion/deflection fittings where conduit movement is expected in more than one dimension, and where conduits transition out of structures in locations where differential settlement may occur.
 3. Encased Expansion Fittings
 - a. Install encased expansion fittings wherever encased conduits cross building expansion joints.
 - b. Deflection type fittings shall not be required for encased conduits crossing an expansion joint within a single structure.
 4. Provide expansion and expansion/deflection fittings constructed of the same material as the raceway to which they are installed.
- J. Install expansion fittings with bonding jumpers wherever raceways cross building expansion joints.
- K. Install exposed raceways at least 1/2 inch from walls or ceilings except that at locations above finished grade where damp conditions do not prevail, install exposed raceways at least 1/4 inch from the face of walls or ceilings by the use of clamp backs or struts.
- L. Wherever contact with concrete or dissimilar metals can produce galvanic corrosion of equipment, provide a means of suitable insulation in order to prevent such corrosion.

3.02 CONDUIT

- A. Provide exposed conduit manufactured of rigid galvanized steel, except as follows and unless indicated otherwise:
1. In areas with chlorine or hydrofluosilicic acid, provide Schedule 40 PVC conduit.
 2. In Class I, Div I or Div II hazardous locations, provide PVC-coated GRS conduit.
 3. For conduit containing only grounding system bonding conductors, provide Schedule 80 PVC conduit.
- B. Power conduit encased in concrete shall be constructed of Schedule 40 PVC.
- C. Analog control or instrumentation conduit shall be GRS.
- D. Concrete Encasement

1. Where PVC or GRS conduit is stubbed up from a concrete encasement, provide a PVC-coated GRS elbow.
 2. The conduit shall emerge from the concrete in a direction perpendicular to the surface whenever possible.
 3. Do not encase conduit in the bottom floor slab below grade.
- E. Size
1. Provide exposed conduit of 3/4-inch minimum trade size.
 2. Provide encased conduit of one-inch minimum trade size.
- F. Install supports at distances required by the NEC.
- G. Concrete cover for conduit and fittings shall not be less than 1-1/2 inches for concrete exposed to earth or weather, or less than 3/4 inch for concrete not exposed to weather or in contact with the ground.
- H. Penetrations
1. Provide conduit passing through walls or floors with plastic sleeves.
 2. Perform core drilling in accordance with the requirements of Section 16050 – General Electrical Work.
 3. Conduits passing through a slab, wall, or beam shall not significantly impair the strength of the construction.
- I. Conduits embedded within a slab, wall, or beam (other than those merely passing through) shall meet the following requirements:
1. Conduits with their fittings embedded within a column shall not displace greater than 4 percent of the gross area of cross section;
 2. Conduits shall not be larger in outside dimension than 1/3 the overall thickness of the slab, wall, or beam in which it is embedded; and,
 3. Conduits shall not be spaced closer than 3 outside diameters on centers.
- J. Place the conduit such that cutting, bending, or displacing reinforcement from its proper location will not be required.
- K. Coat threads with a conductive lubricant before assembly.
- L. Joints
1. Provide joints that are tight, thoroughly grounded, secure, and free of obstructions in the pipe.
 2. Adequately ream the conduit in order to prevent damage to the wires and cables inside.
 3. Use strap-wrenches and vises to install the conduit, in order to prevent wrench marks on the conduit.
 4. Replace conduit with wrench marks.
 5. Where installed in chemical or fuel containment areas, the conduit shall not have joints or fittings located below the top of the containment area to prevent entry of chemicals or fuel into the conduit system.
- M. Slope
1. Wherever possible, slope the conduit runs to drain at one or both ends of the run.
 2. Wherever conduit enters a substructure below grade, slope the conduit in order to drain water away from the structure.

3. Take extreme care in order to avoid pockets or depressions in the conduit.
- N. Where conduits from duct banks enter building walls below grade, transition to PVC-coated GRS at least 12" outside the wall. Installation of PVC-coated rigid steel conduit through a core-drilled hole in an exterior wall below-grade shall utilize a sealing device as manufactured by **Link Seal**, or equal.
- O. Connections
1. Make connections to lay-in-type grid lighting fixtures by using flexible metal conduit not exceeding 4 feet in length.
 2. Make connections to motors and other equipment subject to vibration by using liquid-tight flexible conduit not exceeding 3 feet in length.
 3. Provide equipment subject to vibration that is normally provided with wiring leads with a cast junction box for the make-up of connections.
- P. Provide conduit seal fittings in hazardous classified locations, in strict accordance with the NEC.
- Q. Provide conduit, fittings, and boxes required in hazardous classified areas that are suitably rated for the area, and provide in strict accordance with NEC requirements.
- R. Duct sealant shall be foam duct sealant such as **Polywater FST or approved equal**. Provide duct sealant at the following locations:
1. Where required by NEC Article 300.7.
 2. In areas where chlorine gas or fumes from sodium hypochlorite exist to prevent passage of gas through the raceway system.
- S. Empty Conduits
1. Tag empty conduits at both ends to indicate the final destination.
 2. Where it is not possible to tag the conduit, identify the destination by means of a durable marking on an adjacent surface.
 3. Install a pull-cord in each empty conduit in floors, panels, manholes, equipment, and the like.
 4. Install a removable plug on empty conduits that terminate below grade, in vaults, manholes, handholes, and junction or pullboxes.
- T. Identification of Conduits
1. Identify conduits at ends and at pulling points.
 2. Identification shall be the unique conduit number assigned in the Contract Documents.
 3. Other than 120 VAC panelboard circuits, if a conduit has not been assigned a unique number in the Contract Documents, assign a unique number following the numbering scheme used in the Contract Documents.
 4. Assign a unique number to 120 VAC panelboard circuits, similar to the cable numbering scheme used in the Contract Documents.
 5. Provide conduit identification by a stamped or engraved non-corroding metal tag attached to the conduit bushing.
 6. Provide an engraved phenolic nameplate in accordance with the requirements of Section 16050 – General Electrical Work, or a computer printed self-adhesive label attached to the equipment or enclosure inside which the conduit terminates.
 7. Markings with a pen or paint will not be accepted.
- U. Identification of Pullboxes and Junction Boxes
1. Identify pullboxes and junction boxes.

2. Identification shall be the unique conduit number assigned in the Contract Documents, or if not assigned a unique number the CONTRACTOR shall assign one following the numbering scheme used in the Contract Documents.
 3. Provide box identification by a stamped or engraved non-corroding metal tag or an engraved phenolic nameplate, in accordance with the requirements of Section 16050 – General Electrical Work, and attached to the box or enclosure.
 4. Markings with a pen or paint will not be accepted.
- V. Provide conduit for data cables in accordance with the equipment manufacturer's recommendations, especially regarding separation from low- and medium-voltage power raceways.

END OF SECTION

SECTION 16111
UNDERGROUND RACEWAY SYSTEMS

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. Provide underground raceway systems, complete and in place, as indicated in accordance with the Contract Documents.
- B. Pullboxes, and fittings that are dedicated to the underground raceway system shall comply with the requirements of this Section.

1.02 SUBMITTALS

- A. Furnish submittals in accordance with the requirements of Section 01330 – Submittal Procedures, and Section 16050 – General Electrical Work.
- B. Shop Drawings
 - 1. Submit complete catalog cuts of all raceways, fittings, pullboxes, marked where applicable in order to show proposed materials and finishes.

As-Built Drawings

- 2. Prepare as-built drawings of encased concealed and exposed raceways, ducts, raceways, junction boxes, pull boxes, and electrical and instrumentation equipment.
- 3. Show routings, burial depths, and handhole locations and sizes, and where applicable, connections to drainage systems.

PART 2 - PRODUCTS

2.01 PULLBOXES

- A. Frames and Covers
 - 1. Provide traffic-type covers with an H-20 loading, except as otherwise indicated.
 - 2. Identify pullbox covers as "ELECTRIC" by providing raised letters cast into the covers.
 - 3. Provide frost-proof and water-tight grey iron frames and covers with solid lids and inner lids, and with 28-inch clear openings.
 - 4. Bolt the covers and lids to cast-in-place steel frames using corrosion-resistant hardware.
 - 5. Factory-prime the frames.
 - 6. Provide covers constructed of cast-iron, and provide pick holes.
 - 7. Provide frames with a 1/2-inch drilled and tapped hole and lug in order to accommodate a No. 4/0 AWG bare stranded copper conductor connected to a ground rod and the ground conductor of power cables passing through the pullboxes.
- B. Equip pullboxes with pulling-in irons, opposite and below each ductway entrance.
- C. Provide pullboxes with closed bottoms; open-bottom pullboxes will not be accepted.
- D. Provide PVC ductbank conduits with end bells.
- E. Brackets
 - 1. Provide non-metallic, non-conductive brackets and stanchions in pullboxes as required for racking wiring through the pullboxes. Attach to pullboxes walls using stainless steel anchors and hardware.
 - 2. Brackets and stanchions: **Underground Devices, Inc.**, or equal.

F. Precast Pullboxes Manufacturer, or Equal

1. **Jensen Precast**

2. **Old Castle**

3. **U.S. Precast**

2.02 DUCTBANKS

A. Provide underground ducts constructed of Schedule 40 PVC.

B. Encase ducts in red-dyed concrete with steel reinforcing bars.

C. Provide concrete with a 3,000-psi compressive strength conforming to the requirements of Section 03310 – Cast-in-Place Concrete.

D. Colorant

1. The concrete shall be dyed red throughout the ducts; surface treatment will not be accepted.

2. Provide colorant consisting of an integral red-oxide coloring pigment in the proportion of 8 pounds per cubic yard of concrete.

3. The costs, if any, of cleaning coloring pigment from the concrete delivery equipment and other related cleanings shall be considered as part of the WORK.

E. Grounding

1. Ductbanks shall contain a No. 4/0 bare stranded copper ground wire.

2. The ground wire shall be continuous through the ductbank and terminate at power distribution equipment and the grounding grid.

F. Identification Tape

1. Provide continuous lengths of underground warning tapes located 12 inches above and parallel to the ductbanks.

2. Provide tape consisting of 6-inch wide polyethylene film, imprinted with "CAUTION - ELECTRIC UTILITIES BELOW."

3. Manufacturer, or Equal

a. **Brady**

PART 3 - EXECUTION

3.01 GENERAL

A. Install underground raceways between pullboxes as indicated.

B. Raceway systems shall be electrically and mechanically complete before conductors are installed.

C. Provide bends and offsets that are smooth and symmetrical, and fabricated with tools designed for this purpose.

D. Use factory elbows wherever possible.

E. To the extent possible, follow the raceway routings as indicated on the Drawings.

F. Adjust the indicated routings as necessary in order to avoid obstructions.

G. Coordination with Other Trades

1. Coordinate with other trades prior to installation of raceways.

2. The lack of coordination shall not be justification for extra compensation.

3. Perform removal and re-installation to resolve conflicts as part of the WORK.

3.02 DUCTBANKS

- A. Install ductbanks in accordance with the following criteria:
 - 1. Assemble the duct using high-impact, non-metallic spacers and saddles in order to provide conduits with vertical and horizontal separation.
 - 2. Set the plastic spacers every 5 feet.
 - 3. Anchor the duct array every 5 feet in order to prevent movement during the placement of concrete.
 - 4. Lay the duct on a grade line of at least 3 inches per 100 feet, sloping towards pullboxes.
 - 5. Install the duct and adjust the pullbox depths such that the top of the concrete envelope is a minimum of 18 inches below grade and a minimum of 24 inches below roadways.
 - 6. Accomplish changes in direction of the duct envelope by more than 10 degrees horizontally or vertically by using bends with a minimum radius 24 times the duct diameter.
 - 7. Stagger duct couplings a minimum of 6 inches.
 - 8. Provide select backfill or sand for the bottom of the trench.
 - 9. Cleaning
 - a. Clean each bore of the completed ductbank by drawing through it a standard flexible mandrel, one foot long and 1/4 inch smaller than the nominal size of the duct.
 - b. After passing the mandrel, draw through a wire brush and swab.
 - 10. For spare raceways that are not indicated to contain conductors, provide a 1/8-inch polypropylene pull cord installed throughout the entire length of the raceway.
- B. Grout duct entrances smooth, and terminate ducts with flush end bells.
- C. Assemble sections of pre-fabricated pullboxes using waterproof mastic, and set on a 6-inch bed of gravel as recommended by the manufacturer or as required by field conditions.
- D. Provide watertight ductbank penetrations through walls of pullboxes, and building walls below grade.
- E. Terminate concrete-encased ductbanks at building foundations.
- F. Where ducts enter buildings, provide duct sealant in every duct at the building-end of the duct run to prevent water or condensation entry from the duct bank into the building.
 - 1. Manufacturer, or Equal
 - a. **Polywater FST, FST-MINI**
- G. When duct enters the building on a concrete slab on grade, do not encase the duct but transition to rigid steel PVC-coated conduits on stub-ups.
- H. Sealing
 - 1. Where an underground conduit enters a structure through a concrete roof or a membrane-waterproofed wall or floor, provide a sealing device.
 - 2. Manufacturer, or Equal
 - a. **Link-Seal**
 - 3. Use the sealing device with rigid steel conduit.
 - 4. Transition from PVC to rigid steel conduit prior to building entry.

END OF SECTION

SECTION 16120
WIRE AND CABLING

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. The CONTRACTOR shall provide wire and cable, complete and operable, in accordance with the Contract Documents.
- B. In the event that motors provided are larger horsepower than the motors indicated, raceways, conductors, starters, overload elements, and branch circuit protectors shall be revised as necessary to control and protect the increased motor horsepower in accordance with Section 16460 – Electric Motors. Revisions are part of the WORK of this Section.

1.02 SUBMITTALS

- A. The CONTRACTOR shall submit Shop Drawings in accordance with Sections 01330 – Submittal Procedures and 16050 – General Electrical Works.
- B. Submit catalog cuts and material list for each conductor type. Indicate insulation material, conductor material, voltage rating, manufacturer and other data pertinent to the specific cable, such as type shielding, number of pairs and applicable standards.
- C. Submit cable test results in accordance with this Section as well as Section 16950 – Electrical Tests.

1.03 DELIVERY, STORAGE AND HANDLING

- A. The CONTRACTOR shall protect all cables from damage at all times.
- B. Cable ends shall be protected from water entry in accordance with the manufacturer's recommended procedures. Cable ends shall not be left open in manholes or other locations subject to submergence. If the cable ends become submerged prior to splicing or termination, the cables shall be replaced in their entirety.
- C. Cables shall be pulled into raceways in accordance with the manufacturer's requirements. Under no circumstances shall cable pulling tensions exceed the manufacturer's written instructions.
- D. Pulling tensions on raceway cables shall be within the limits recommended by the cable manufacturer. Wire pulling lubricant, where needed, shall be UL approved.

PART 2 - MATERIALS

2.01 GENERAL – LOW-VOLTAGE CABLE

- A. Conductors, include grounding conductors, shall be stranded copper. Aluminum conductor and/or solid conductor wire and cable will not be permitted. Insulation shall bear the UL label, the manufacturer's trademark, and identify the type, voltage, and conductor size. Conductors except flexible cords and cables, fixture wires, and conductors that form an integral part of equipment such as motors and controllers shall conform to the requirements of Article 310 of the National Electric Code, latest edition, for current carrying capacity. Flexible cords and cables shall conform to Article 400, and fixture wires shall conform to Article 402. Wiring shall have wire markers at each end.

2.02 LOW-VOLTAGE POWER AND LIGHTING CONDUCTORS

- A. Wire rated for 600 volts in duct or conduit for power and lighting circuits shall be single conductor, Class B Type XHHW-2 cross-linked polyethylene conforming to UL-44 - UL Standard for Thermoset-Insulated Wires and Cables.

1. THHN/THWN wire shall not be permitted to be used for any power or control wiring in this project, except as specifically permitted within control panels.
- B. Conductors for feeders as defined in Article 100 of the NEC shall be sized to prevent a voltage drop exceeding 3 percent at the farthest outlet of power, heating, and lighting loads, or combinations of such loads, and where the maximum total voltage drop on both feeders and branch circuits to the farthest connected load does not exceed 5 percent.
- C. Wiring for 600-volt class power and lighting shall be as manufactured by **Okonite, General Cable, Southwire**, or approved equal.

2.03 LOW-VOLTAGE CONTROL CONDUCTORS

- A. Low voltage control wire in duct or conduit shall be the same type as power and lighting wire indicated above.
- B. Control wiring shall be No.14 AWG.
- C. Control wires inside panels and cabinets shall be machine tool grade type MTW, UL approved, rated for 90 degrees C at dry locations, and be as manufactured by **American, General Cable**, or approved equal.

2.04 INSTRUMENT CABLE

- A. Instrumentation cable shall be rated at 300 volts, minimum.
- B. Individual conductors shall be No. 16 AWG stranded, tinned copper. Insulation shall be color coded polyethylene: black-clear for 2 conductor cable and black-red-clear for 3 conductor cable.
- C. Instrumentation cables shall be composed of the individual conductors, an aluminum polyester foil shield, a No. 18 or larger AWG stranded, tinned copper drain wire, and a PVC outer jacket with a thickness of 0.047-inches.
 1. Single pair, No. 16 AWG, twisted, shielded cable shall be **Belden Part No. 8719**, similar by **General Cable**, or equal.
 2. Single triad, No. 16 AWG, twisted, shielded cable shall be **Belden Part No. 8618**, similar by **General Cable**, or equal.

2.05 VARIABLE FREQUENCY DRIVE CABLE

- A. VFD power cable shall be three (3) conductor, stranded copper, PVC jacketed, shielded type, tray cable (TC) rated 1000 volts with three (3) symmetrical ground conductors. The individual conductors shall be UL listed as Type XHHW-2 rated for 90 degrees C at wet and dry locations, with XLPE insulation.
- B. VFD Cables shall be as manufactured by **Belden, Southwire, OLFLEX**, or equal.

2.06 CABLE SPLICES AND TERMINATIONS

- A. Where cable lugs are required for power cable terminations, utilize compression lugs – **3M** Scotchlok 30000 and 31100 Series, **Penn Union** HBBLU and BLU, **Burndy** Hylug, or equal. Utilize compression tools as recommended by the manufacturer. Pressure type, twist-on connectors (wire nuts) will not be acceptable.
- B. Pre-insulated fork tongue lugs shall be **Thomas & Betts, Burndy**, or equal.
- C. General purpose insulating tape shall be **Scotch No. 33, Plymouth Slip-knot**, or equal. High temperature tape shall be polyvinyl as manufactured by **Plymouth, 3M**, or equal.
- D. Labels for coding 600-volt wiring shall be computer printable or pre-printed, self-laminating, self-sticking, as manufactured by **W.H. Brady, 3M**, or equal.
- E. Stress cone material for make-up of medium voltage shielded cable shall be as manufactured by **Raychem, 3M**, or equal.

- F. Shielded power cable shall be spliced using kits specifically designed to splice medium voltage, shielded power cables. Splice kits shall be designed for continuous submergence. Heat shrink splice kits shall be **Raychem "Type HVS"**, or equal. "Cold" shrink splice kits shall be **3M "5760 Series"**, or equal. The CONTRACTOR's personnel shall be trained by the splice kit manufacturer for proper installation of the splices, and shall submit certification of training as a shop drawing. A certified trainee shall perform the splice work.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. The CONTRACTOR shall provide, terminate and test all power, control, and instrumentation conductors.
- B. The CONTRACTOR shall, as a minimum, provide the number of control wires listed in the conduit schedule or on the Contract Drawings. Excess wires shall be treated as spares for future use.
- C. Conductors shall not be pulled into any raceway until raceway has been cleared of moisture and debris.
- D. Instrumentation wire shall not be run in the same raceway with power and control wiring except where specifically indicated.
- E. Wire in panels, cabinets, and wireways shall be neatly grouped using nylon tie straps, and shall be neatly fanned out to terminals.
- F. Single conductor cable in cable trays shall be No. 1/0 or larger and shall be of a type listed and marked for use in cable trays. Tray cable smaller than 1/0 shall be multi-conductor, with outer jacket.

3.02 FIELD ASSEMBLY

A. General

1. Wire taps and splices shall be properly taped and insulated according to their respective classes.
2. In general, there shall be no cable splices in underground manholes or pullboxes. If splices are necessary, the cables shall be spliced using submersible cable splices, suitable for continuous submergence. Splices in underground manholes and pullboxes may be made only with the approval of the ENGINEER.
3. Stranded conductors shall be terminated directly on equipment box lugs making sure that conductor strands are confined within lug. Use forked-tongue lugs where equipment box lugs have not been provided.
4. Excess control and instrumentation wires shall be long enough to terminate at any terminal block in the enclosure, be properly taped, be identified with origin, and be neatly coiled.

B. Control Wire and Cable

1. Control conductors shall be spliced or terminated only at the locations indicated and only on terminal strips or terminal lugs of vendor furnished equipment.
2. In motor control centers, and control panels, control wire and spare wire shall be terminated to terminal strips.
3. The CONTRACTOR shall provide as a minimum the number of control wires listed in the conduit schedule or as indicated in the Contract Documents. Excess wires shall be treated as spares.

C. Instrumentation Wire and Cable

1. Shielded instrumentation cables shall be grounded at one end only, preferably the receiving end on a 4 - 20 mA system.
2. Two and 3 conductor shielded cables installed in conduit runs which exceed available standard cable lengths may be spliced in pullboxes with the prior approval of the ENGINEER. Such cable runs shall have only one splice per conductor.

D. Power Wire and Cable

1. 120/208-volt, 120/240-volt, and 480/277-volt branch circuit conductors may be spliced in suitable fittings at locations determined by the CONTRACTOR. Cables rated above 2,000 volts shall be spliced or terminated only at equipment terminals indicated.
2. Splices to motor leads in motor terminal boxes shall be wrapped with mastic material to form a mold and then shall be taped with a minimum of 2 layers of varnished cambric tape over-taped with a minimum of 2 layers of high temperature tape.
3. Shielded power cable shall be terminated with pre-assembled stress cones in a manner approved by the cable and terminal manufacturer. The CONTRACTOR shall submit the proposed termination procedure as a Shop Drawing.
4. VFD shielded power cables shall have the shield grounded at all locations where it is exposed.

3.03 IDENTIFICATION

A. Cable Identification

1. Wire and cable shall be identified for proper control of circuits and equipment and to reduce maintenance effort. Identification shall be installed at every termination point.
2. For termination of individual conductors, provide heat shrink sleeve markers, Brady Permasleeve or approved equal.
3. For cables routed through handholes, pull boxes, manholes, motor control centers, switchboards, and switchgear, provide 2-inch round, 20-gauge Type 304 stainless steel tags. Stamp with ¼-inch high lettering identifying the cable identifier.
4. Identification Numbers
 - a. The CONTRACTOR shall assign to each control and instrumentation wire and cable a unique identification number. Numbers shall be assigned to conductors having common terminals and shall be shown on "as built" drawings. Identification numbers shall appear within 3-inches of conductor terminals. "Control and Instrumentation Conductors" shall be defined as any conductor used for control, interlock, alarm, annunciator, or signal purposes.
 - b. Multiconductor cable shall be assigned a number which shall be attached to the cable at intermediate pull boxes and at stub-up locations beneath free-standing equipment. It is expected that the cable number shall form a part of the individual wire number. Individual control conductors and instrumentation cable shall be identified at pull points as described above. The instrumentation cable numbers shall incorporate the loop numbers assigned in the Contract Documents.
 - c. Color Coding of Power Wire: Provide color coding throughout the entire network of feeders and circuits (600 volts and below) as follows:

Phase	240/120 Volts	208/120 Volts	240 Volts	480/277 Volts
Phase A	Black	Black	Black	Brown

Phase B	Red	Red	Red	Orange
Phase C	---	Blue	Blue	Yellow
Neutral	White	White	White	Gray
Ground	Green	Green	Green	Green

- d. Insulated ground wire shall be green, and neutral shall be gray. Color coding and phasing shall be consistent throughout the Site, but bars at panelboards, switchboards, and motor control centers shall be connected Phase A-B-C, top to bottom, or left to right, facing connecting lugs.
- e. Color coding tape shall be used where colored insulation is not available. Colored identification tape may be used on conductors between the local disconnect and the load, where permitted by the NEC. Any phase changes necessary for proper rotation shall be made at the driven equipment where colored insulation is used. Phase changes may be made on the load side of the local disconnect, where phase colors are identified using tape.
- f. General purpose AC control cable shall be red. General purpose DC control cable shall be blue.
- g. Spare cable shall be terminated on terminal screws and shall be identified with a unique number as well as with destination.
- h. Terminal strips shall be identified by computer printable, cloth, self-sticking marker strips attached under the terminal strip.

3.04 FIELD QUALITY CONTROL

- A. Cable Assembly and Testing: Cable assembly and testing shall comply with applicable requirements of ICEA Publication No. S-95-658/NEMA WC70 - Ethylene-Propylene-Rubber Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
- B. Factory test results shall be submitted in accordance with Section 01330 – Submittal Procedures, prior to shipment of cable. The following field tests (in addition to the tests specified in Section 16950 – Electrical Tests) shall be the minimum requirements:
 - 1. Insulation resistance testing, using a DC megohmmeter, shall be performed on cables operating at more than 2,000 volts to ground. Time-resistance readings shall be taken and recorded at intervals of 30 seconds and one minute. Time-resistance voltage levels shall be per the cable manufacturer's recommendations.
 - 2. Power cable rated at 600 volts shall be tested for insulation resistance between phases and from each phase to a ground using a megohmmeter.
 - 3. Field testing shall be done after cable is installed in the raceways.
 - 4. Field tests shall be performed by a NETA-certified test organization. Test results shall be submitted to the ENGINEER for review and acceptance.
 - 5. Cables failing the tests shall be replaced with a new cable or be repaired. Repair methods shall be as recommended by the cable manufacturer and shall be performed by persons certified by the industry.
- C. Continuity Test: Control and instrumentation cable shall be tested for continuity, polarity, undesirable ground, and origination. Such tests shall be performed after installation and prior to placing cable in service.

END OF SECTION

SECTION 16140
WIRING DEVICES

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. The CONTRACTOR shall provide wiring devices, complete and operable, as indicated in accordance with the Contract Documents.
- B. The requirements of Section 16050 – General Electrical Work, apply to this Section.
- C. Single Manufacturer
 - 1. Like products shall be the end product of one manufacturer in order to achieve standardization of appearance, operation, maintenance, spare parts, and manufacturer's services.

1.02 SUBMITTALS

- A. Furnish submittals in accordance with the requirements of Section 01330 – Submittal Procedures.
- B. Shop Drawings
 - 1. Submit complete catalog cuts of switches, receptacles, enclosures, covers and appurtenances, marked to clearly identify the proposed materials.
 - 2. Submit documentation showing that the proposed materials comply with the requirements of NEC and U.L.
 - 3. Submit documentation of the manufacturer's qualifications.

PART 2 - PRODUCTS

2.01 GENERAL

- A. Devices shall carry the U.L. label, and shall be designed for use with stranded copper conductors.
- B. Color
 - 1. General purpose duplex receptacles and toggle switch handles shall be Brown everywhere except unless otherwise indicated.
 - 2. Special purpose receptacles shall have a body color as indicated.
- C. Receptacles and switches shall be of specification grade and shall conform to NEMA WD-1, Federal Specifications W-C-596E and W-S-896E, respectively.

2.02 GENERAL PURPOSE RECEPTACLES

- A. Duplex receptacles shall be of the polarized 3-wire type for use with a 3-wire cord with grounded lead, and one designated stud shall be permanently grounded to the conduit system in accordance with NEC article 406.4.
- B. Dry Areas
 - 1. NEMA Configuration #5-20R: duplex receptacle rated 125V, 20A
 - a. **Leviton:** #5362
 - b. **Hubbell:** #HBL5362
 - c. **Pass and Seymour:** #5362A
 - d. **Or Equal**
 - 2. NEMA Configuration #5-30R single receptacle rated 125V, 30A
 - a. **Leviton:** #5371
 - b. **Hubbell:** #HBL9308

c. **Or Equal**

C. Damp/Wet Areas

1. Receptacles for damp/wet locations shall be weather-resistant with extra duty, in-use listed covers in accordance with NEC Article 406.8.

D. GFCIs

1. Ground-fault circuit-interrupting receptacles (GFCIs) shall be installed at the indicated locations and as required by the NEC.
2. GFCIs shall be duplex receptacles, of specification grade, and tripping at 5 mA.
3. GFCI ratings shall be 125V, 20 amperes, NEMA WD-1, Configuration 5-20R, and capable of interrupting 5,000 amperes without damage.
4. GFCIs shall be weather resistant-listed in accordance with NEC Article 406.8.
5. Feed-through-type GFCIs serving standard receptacles will not be permitted.
 - a. **Leviton:** G5362-WT
 - b. **Hubbel:** GFR5362SG
 - c. **Or Equal**

E. Hazardous Locations

1. Receptacles for hazardous locations shall be of the single-gang type with a spring door.
2. The receptacles shall be provided with a factory-sealed chamber.
3. The receptacles shall be provided with a delayed action feature requiring the plug to be inserted into the receptacle and rotated before the electrical connection is made.
4. The receptacle shall not work with non-hazardous rated plugs.
5. One plug shall be furnished with each receptacle.
6. The receptacles shall be rated for 20 amps at 125 VAC.
 - a. **Appleton:** EFSB
 - b. **Crouse-Hinds:** ENR
 - c. **Hubbell Killark:** UGR
 - d. **Or Equal**
7. Ground-Fault Protection: where indicated, hazardous location receptacles shall be provided with ground fault protection.
 - a. **Appleton** EFSR-GFI
 - b. **Crouse-Hinds** GFS-1
 - c. **Hubbell Killark:** UGRGF
 - d. **Or Equal**

2.03 ENCLOSURES AND COVERS

- A. Surface-mounted switches and receptacles shall be housed in FS or FD-type weatherproof conduit fittings.
- B. Switch and receptacle covers on surface-mounted boxes shall be constructed of die-cast copper-free aluminum.
 1. **Appleton:** FSK
 2. **Crouse-Hinds:** DS185 and WLRD-1
 3. **Hubbell Killark:** FZ and FC
 4. **Or Equal**
- C. In finished areas, switch and receptacle covers shall be constructed of stainless steel.

D. Wet Locations

1. Receptacles in wet locations shall be provided with a hinged non-metallic Clear cover/enclosure marked "Suitable for Wet Locations when in use" and "UL Listed."
2. Provide a gasket between the enclosure and the mounting surface, and between the hinged cover and mounting plate/base.
 - a. **Appleton:** WCIU
 - b. **Crouse-Hinds:** TP74
 - c. **Hubbell TayMac:** Extra Duty
 - d. **Or Equal**

2.04 NAMEPLATES

- A. Provide nameplates or equivalent markings on the switch enclosures to indicate the ON and OFF positions of each switch.
- B. ON and OFF for 3-way or 4-way switches will not be accepted.
- C. Provide receptacles for special purposes with nameplates indicating their use.
- D. Nameplates shall meet the requirements of Section 16050 – General Electrical Work.

PART 3 - EXECUTION

3.01 GENERAL

- A. Perform WORK in accordance with the requirements of the NEC.

3.02 CONNECTION

- A. Rigidly attach wiring devices in accordance with the NEC and as indicated, avoiding interference with other equipment.
- B. Securely fasten nameplates using screws, bolts, or rivets centered under or on the device, unless otherwise indicated.
- C. Receptacles indicated to be powered by uninterruptible power supplies (UPS) shall have a nameplate installed directly above the receptacle that reads:
 1. (first line) "UPS-POWERED"
 2. (second line) "NO TOOLS"
- D. Nameplates shall meet the requirements of Section 16050 – General Electrical Work, General, and shall consist of a red plate with white letters a minimum of 1/4 inch tall.

3.03 GROUNDING

- A. Devices, including switches and receptacles, shall be grounded in accordance with NEC, Article 250, and Section 16450 – Grounding.
- B. Switches and associated metal plates shall be grounded through the switch mounting yoke, outlet box, and raceway system.
- C. Flush Receptacles
 1. Flush receptacles and their metal plates shall be grounded through positive ground connections to the outlet box and grounding system.
 2. Maintain the ground to each receptacle by a spring-loaded grounding contact to the mounting screw, or by a grounding jumper, each making a positive connection to the outlet box and grounding system at all times.
- D. Receptacles served from an uninterruptible power supply shall be provided with an isolated grounding conductor from the serving power panelboard.

3.04 FIELD TESTING

- A. Provide checkout, field, and functional testing of wiring devices in accordance with Section 16050 – General Electrical Work.
- B. Test each receptacle for polarity and ground integrity, using a standard receptacle tester.

END OF SECTION

SECTION 16155
LOW-VOLTAGE MOTOR CONTROL CENTERS

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. The CONTRACTOR shall provide motor control centers (MCCs), complete and operable, in accordance with the Contract Documents.
- B. The requirements of Section 16050 – General Electrical Work, apply to the WORK of this Section.
- C. In the event that provided motors are of greater horsepower than the indicated motors, revise the raceways, conductors, starters, overload elements, and branch circuit protectors as necessary in order to control and protect the increased motor horsepower in accordance with Section 16460 – Electric Motors.
- D. Single Manufacturer
 - 1. The MCCs shall be the end product of one manufacturer in order to standardize appearance, operation, maintenance, spare parts, and manufacturer's services.
 - 2. This requirement, however, does not relieve the CONTRACTOR of overall responsibility for the WORK.
- E. Coordination
 - 1. The equipment provided under this Section shall operate the electric motor driver with the driven equipment as indicated under other equipment Sections.
 - 2. The MCC manufacturer shall be provided with the following information, at a minimum:
 - a. Section 16050 General Electrical Work
 - b. Section 16460 Electric Motors
 - c. Section 16950 Electrical Tests
 - d. Electrical Contract Drawings

1.02 SUBMITTALS

- A. Furnish submittals in accordance with Section 16050 – General Electrical Work.
- B. Furnish the following equipment information in the Shop Drawings:
 - 1. NEMA rating and color of enclosure
 - 2. horizontal and vertical bus ampacities, voltage rating, interrupting capacity, and materials of construction
 - 3. ground bus size and material of construction
 - 4. conduit entrance provisions
 - 5. main incoming line entry provision (top or bottom)
 - 6. control unit nameplate schedule
 - 7. circuit breaker types, frames, and settings
 - 8. starter NEMA sizes, auxiliary contact provisions, and coil voltage
 - 9. relays, timers, pilot devices, control transformer VA and fuse sizes
 - 10. MCC Wiring Diagrams
 - a. Furnish custom elementary schematic ladder diagrams for each compartment.
 - b. The ladder diagrams shall include remote devices.

- c. Submittals not meeting these requirements will not be reviewed further and will be returned to the CONTRACTOR.
 - 11. Short circuit rating of the complete assembly
 - 12. Replacement parts lists and operation and maintenance procedures
 - 13. Seismic design certification of the anchoring system in accordance with Section 16050 – General Electrical Work.
 - 14. Time-current curves for protective devices
 - 15. VFD Equipment Information
 - a. name of starter and drive manufacturer
 - b. type and complete model number
 - c. assembly drawing and nomenclature, including enclosure dimensions, mounting and anchoring details, and internal layout
 - d. detailed schematics, including external wiring connections
 - e. maximum heat dissipation capacity in kW
 - f. altitude de-rating information
 - 16. factory test data certifying compliance with requirements of similar equipment from the same manufacturer
- C. Spare Parts List
- 1. Furnish spare parts information for parts required by this Section as well any other spare parts recommended by the MCC manufacturer.

PART 2 - PRODUCTS

2.01 GENERAL

- A. The manufacturer of the low-voltage motor control center shall also manufacture at least the following:
 - 1. molded case circuit breakers, up to and including 225 ampere frame size
 - 2. disconnect switches
 - 3. magnetic motor starters
 - 4. control and timing relays rated at 600 volts AC
 - 5. pushbuttons, lights and selector switches, including remote mounted control stations
 - 6. meters, including ammeter, voltmeter, and solid-state metering devices
- B. Single Manufacturer
 - 1. Devices of the same type shall be products of the same manufacturer.
 - 2. This requirement applies to control devices, custom-fabricated equipment, and insofar as practical to equipment manufactured on a production basis.
- C. Motor control centers shall conform to the standards for NEMA Class IIS, Type B diagrams and wiring showing all field connections. Tag control wiring within 2 inches of termination at each device and terminal board. Schematics shall also show terminal numbers and interior and field wire numbers.
- D. MCC Schedule

MCC DESIGNATION	LOCATION
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MCC-06-01	Near RAS PS, outside classified location.

2.02 DESIGN, CONSTRUCTION, AND MATERIAL REQUIREMENTS

- A. The motor control centers shall be 600-volt class and suitable for operation on a 3-phase, 60-Hz system.
- B. The system operating voltage and number of wires shall be as indicated.
- C. Power
 - 1. The motor control center shall receive power from a 3-phase, from existing MCC-05-01 480-volt 3-PH 3W system.
 - 2. Power distribution from the MCC shall be 480-volt, 3-phase, 3-wire.
- D. Enclosure
 - 1. The enclosure shall be of NEMA Type NEMA-3R.
 - 2. Compartment doors shall be interlocked with compartment circuit breakers, fitted with a maintenance override.
 - 3. Latches for panelboard compartments shall have butterfly heads or another hand operable method that does not require tools to operate.
- E. Size and Arrangement
 - 1. Motor control centers shall be configured as mechanical groupings of control center units, assembled into a lineup of control center sections.
 - 2. Each control section shall be nominally 90 inches tall by a minimum of 20 inches deep.
 - 3. MCCs shall be designed to not exceed the indicated spatial requirements, including spaces, spares, and future compartments.
 - 4. MCCs shall be subject to rejection if they exceed the indicated lengths, where allotted space is critical.
 - 5. Equipment within the MCC may be rearranged at the discretion of the manufacturer, providing that the MCC includes the spares, space, and future provisions as indicated.
 - 6. Switches and circuit breakers used as switches shall be located such that the center of the grip of the operating handle of the switch or circuit breaker, when in its highest position, will not be more than 6 feet, 7 inches above the floor, including the height of the concrete pad.
- F. Components
 - 1. Busses
 - a. Provide a continuous copper ground bus, full width of the motor control center line-up.
 - b. Horizontal Busses
 - The main horizontal bus shall be of tin-plated copper, and located within an isolated compartment.
 - The bus shall be rated for 600 amperes minimum, but in no case less than the main lug or main breaker frame size.
 - c. Vertical Busses
 - The vertical bus in each section shall consist of a single tin-plated copper conductor per phase, with a current capacity of not less than 300 amps.

- The vertical bus shall be completely isolated and insulated, and shall extend the full height of the section wherever possible.

d. Power buses shall be braced to withstand 65,000 amperes, minimum.

2. Wireways

- a. Provide a separate vertical wireway adjacent to each vertical unit, covered by a hinged door.
- b. Each individual unit compartment shall be provided with a side barrier to permit pulling wire in the vertical wireway without disturbing adjacent unit components.
- c. Full height (72-inch) compartments or sections are not required to have a separate wireway.

3. Control wires shall be color coded in accordance with Section 16120 – Wires and Cabling.

G. Cabinets

1. Structural members shall be fabricated of not less than 12-gauge steel, and side and top panels and doors shall be fabricated of not less than 14-gauge steel.

2. Spaces designated as SPACE or BLANK shall include blank hinged doors and vertical bus bars.

3. Control units inside compartments shall be clearly identified with tags or stencil markings.

4. Identification

a. Each control unit, including spares, spaces and blanks, lights, and devices shall be identified by an engraved nameplate.

b. Identification shall include the indicated circuit number.

c. Each motor control center shall be fitted with the manufacturer's nameplate which shall include the NEMA Standard electric rating and other pertinent data, including manufacturer, sales order number, date of manufacture, and place of manufacture.

5. Where "L" or "U" shaped MCC layouts are indicated, corner compartments shall have similar current and short circuit ratings as functional compartments.

6. Fans, heat exchangers, transformers, capacitors, junction boxes, and other devices shall not be mounted on the outside of the motor control center enclosure.

7. Protective Coating

a. The finish for motor control center shall be light grey: ANSI 61 or 49.

b. The panels shall be coated with 2 coats of primer inside and out, and 2 coats of enamel finish.

c. External colors other than ANSI 61 or 49 will not be accepted.

2.03 MAIN AND FEEDER CIRCUIT BREAKERS (480 V)

A. Circuit breakers having a frame size of 150 amperes or less shall be molded-case type with thermal magnetic non-interchangeable, trip-free, sealed trip units.

B. Circuit breakers with a frame size of 225 amperes to 1,200 amperes shall be molded case with interchangeable thermal, and adjustable magnetic trip elements with the following adjustments:

- 1. long-time setting (by changing the unit)
- 2. long-time delay
- 3. short-time setting
- 4. short-time delay

- 5. instantaneous setting
- 6. ground-fault setting
- 7. ground-fault delay
- C. The interrupting capacity of the main and feeder branch circuit breakers shall be a minimum of 65,000 RMS symmetrical amperes.
- D. Service disconnects rated 1000 amps or greater shall provide for ground fault protection of the equipment.
- E. Circuit breaker disconnect operators shall be capable of accommodating 3 padlocks for locking in the OPEN position.
- F. Circuit breaker auxiliary contacts shall be furnished where indicated.

2.04 MOTOR STARTERS

- A. Motor starters shall be mounted in standard motor control center assemblies, arranged as indicated.
- B. Components
 - 1. Each motor starter unit shall consist of a combination magnetic contactor and short circuit protective device, mounted in a completely enclosed cubicle.
 - 2. The short circuit protective device shall be an instantaneous, magnetic only circuit breaker: **Cutler-Hammer Type HMCP, G.E. Mag-Break Motor Circuit Protector**, or equal.
 - 3. Circuit breakers provided as part of a motor starter unit shall be capable of being padlocked in the OPEN position.
 - 4. Resetting of thermal overload elements shall be possible with the unit door closed.
 - 5. Provide 3-phase overload trip units to suit the full load current of the equipment installed, and the trip unit shall be adjusted as required for power factor correction capacitors.
- C. Magnetic Starters
 - 1. Magnetic starters shall have auxiliary contacts as indicated, including N-O and N-C contacts as indicated, plus one each spare N-O and N-C contact.
 - 2. The combination motor starters shall be drawout-type for Size 5 and below.
 - 3. The fixed-type unit assembly shall be constructed such that it can be easily removed from its panel after disconnecting the wires to the terminal block and withdrawing from the primary bus.
 - 4. Removal of a unit assembly shall be possible without rear access and without disturbing any other unit in the motor control center.
- D. Control Power Transformer
 - 1. Each starter unit shall have its own control power transformer, with a 115-volt grounded secondary.
 - 2. Provide one secondary fuse and 2 primary fuses.
 - 3. Control power transformers shall be sized to accommodate the indicated control devices.
 - 4. Local control devices shall be mounted independently of the cover door.
 - 5. Starters shall have a local "RED" RUNNING indicator, "GREEN" READY indicator, and "AMBER" FAIL indicator.
 - 6. Starters shall be provided with elapsed time meters, HAND-OFF-AUTO selector switches, and other devices as indicated in Elementary Diagrams.

7. Cubicle control wires shall be terminated at a pull-apart disconnecting terminal block located at the cubicle.
- E. Identification
1. The motor control center manufacturer shall be responsible for identifying each control wire within each motor starter unit with permanent sleeve-type plastic markers.
 2. Each control wire shall be identified at both ends.
- F. Full-Voltage Starters
1. Full-voltage motor starter units shall be NEMA Size 1 or larger.
 2. Each combination starter shall be rated for a minimum 65,000 RMS symmetrical amperes.
- G. NEMA Ratings
1. Motor starters shall be designed to NEMA ratings.
 2. Starters designed to IEC ratings or with dual IEC/NEMA ratings will not be accepted, either as part of an MCC, as remote starters, or as part of an equipment package.
- H. Solid-State Reduced-Voltage Starters
1. Full-voltage bypass contactors, input contactors, output contactors and other components shall be provided where indicated.
- I. Unless otherwise indicated, 2-speed starters shall be of the 2-winding type.
- J. Variable Frequency Drives
1. Variable frequency drives (VFDs) shall be in accordance with the requirements of Section 16260 – Variable Frequency Drives.
 2. An externally mounted line reactor, cooling fan, and bypass contactor will not be accepted.
 3. Full-voltage bypass contactors, input contactors, output contactors and other components shall be provided where indicated.

2.05 FACTORY TESTS

- A. Provide the manufacturer's standard electrical and mechanical production tests and inspections for motor control centers and their components.
- B. The tests shall include electrical continuity check, dielectric tests for each circuit, and inspection for proper functioning of components including controls, protective devices, metering, and alarm devices.

2.06 SPARE PARTS

- A. The CONTRACTOR shall furnish the following for each MCC:
1. Unit Control Transformer: one of each size furnished in magnetic starters installed
 2. Bezels: 3 of each color installed for pilot indicators
 3. LED Indicators: 3 of each LED type indicators.
 4. Panel Lamps: one dozen of each type (form, voltage and current rating) installed
 5. Control Fuses: one dozen of each type (form, voltage and current rating) installed
 6. Relays: 3 of each type and size installed
- B. Spare parts shall be identified by MCC number, type, size, and manufacturer.

2.07 MCC MANUFACTURER, OR EQUAL

- A. **EATON Cutler-Hammer Freedom "2100" Series**
- B. **General Electric "8000 Line"**

C. Schneider Square-D, Model 6

PART 3 - EXECUTION

3.01 GENERAL

- A. The CONTRACTOR shall install motor control centers in accordance with the manufacturer's published instructions.
- B. Conduit installation shall be coordinated with the manufacturer's as-fabricated drawings such that conduit stub-ups are within the area allotted for conduit.
- C. Conduit shall be stubbed up in the section that contains the devices to which conductors are terminated.

3.02 STORAGE AND HANDLING

- A. If stored at the Site, motor control centers shall be stored in a clean, dry space.
- B. Factory wrapping shall be maintained or an additional heavy plastic cover shall be provided to protect units from dirt, water, construction debris, and traffic.
- C. The storage space shall be heated or the MCC space heaters shall be energized.
- D. Motor control centers shall be handled carefully to avoid damage to motor control center components, enclosure, and finish.
- E. Damage shall be repaired before installation.

3.03 MANUFACTURER'S SERVICES

A. General

- 1. An authorized Service Representative of the manufacturer shall be present at the Site for **3** Work Days in order to provide the services listed below.
- 2. For the purpose of this paragraph, a Work Day is defined as an 8-hour period, excluding travel time.
- 3. The service representative's resume shall be approved by the ENGINEER before training is scheduled.

B. Inspection, Startup, Field Adjustment

- 1. The Service Representative shall supervise the following items, and shall certify that the equipment and controls have been properly installed, aligned, and readied for operation:
 - a. installation of the equipment
 - b. inspection, checking, and adjusting of the equipment
 - c. startup and field testing for proper operation
 - d. performance of repairs to correct any discrepancies or problems revealed during startup and testing
 - e. performance of field adjustments to ensure that the equipment installation and operation comply with the indicated requirements
 - f. Preparation and submittal of a report covering startup and testing, including a listing of equipment settings and parameters at the end of startup and testing.

3.04 INSTALLATION

- A. Motor control centers shall be installed on 3-1/2-inch concrete pads and in accordance with the requirements of Section 16050 – General Electrical Work, unless otherwise noted on Contract Drawings.

- B. After leveling and shimming, the CONTRACTOR shall anchor motor control centers to the concrete pads, and shall grout such that no space exists between the pad and support beams.
- C. The CONTRACTOR shall:
1. torque bus bar bolts to manufacturer's recommendations, and tighten sheet metal and structure assembly bolts;
 2. adjust motor circuit protector (MCP) devices to the instantaneous trip setting position recommended for the actual horsepower and full load amps of the motor;
 3. verify that overload devices are proper for equipment installed;
 4. make necessary changes in overload devices as required for motors having power factor correcting capacitors;
 5. touch up scratches after the equipment has been installed;
 6. verify that nameplate, and other identification is accurate.

3.05 FIELD TESTS

- A. Provide a visual and mechanical inspection after installation, as follows:
1. Inspect for physical damage, proper anchorage, and grounding.
 2. Verify that the ratings of the thermal overload heaters match the motor full-load current nameplate data.
 3. Check tightness of bolted connections.
- B. Electrical Tests
1. Insulation Tests
 - a. Measure the insulation resistance of each bus section phase-to-phase and phase-to-ground for one minute.
 - b. The test voltage and minimum acceptable resistance shall be in accordance with manufacturer's recommendations.
 - c. Measure the insulation resistance of each starter section phase-to-phase and phase-to-ground with the starter contacts closed and the protective device open.
 - d. The test voltage and minimum acceptable resistance shall be in accordance with the manufacturer's recommendations.
 - e. Measure the insulation resistance of each control circuit with respect to ground.
 2. Verify the proper operation of control logic in each mode of control.

END OF SECTION

SECTION 16260
VARIABLE FREQUENCY DRIVE UNITS

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. General

1. The CONTRACTOR shall provide variable frequency drive (VFD) units, complete and operable, as indicated in accordance with the Contract Documents.
2. It is the intent of this Section to require complete, reliable, and fully tested variable frequency drive systems suitable for attended or unattended operation.

B. The requirements of Section 16050 – General Electrical Work, apply to the WORK of this Section.

C. Single Manufacturer

1. Like products shall be the end product of one manufacturer in order to standardize appearance, operation, maintenance, spare parts, and manufacturer's services.
2. This requirement, however, does not relieve the CONTRACTOR of overall responsibility for the WORK.

D. Coordination

1. Equipment provided under this Section shall operate the electric motor driver and the driven equipment as indicated under other equipment specification Sections.
2. The CONTRACTOR'S attention is specifically directed to the need for proper coordination of the WORK under this Section and the WORK under the equipment Section with the WORK under Section 16460 – Electric Motors.

1.02 SUBMITTALS

A. Furnish submittals in accordance with the requirements of Section 01330 – Submittal Procedures, except that Shop Drawing information for the drives shall be submitted as part of the information for the driven equipment.

B. Shop Drawings: Include the following information:

1. Equipment Information

- a. name of drive manufacturer
- b. type and model
- c. assembly drawing and nomenclature
- d. maximum heat dissipation capacity in kW

2. conduit entrance provisions

3. circuit breaker type, frames, and settings

4. information related to relays, timers, pilot devices, control transformer VA, dV/dT devices, line reactors and fuse sizes, including catalog cuts

5. Wiring Diagram

- a. Submit the system schematic wiring diagram and interconnection diagrams.
- b. The schematic ladder diagram shall include remote devices.
- c. The ladder diagram shall incorporate the control logic on the corresponding elementary schematic as indicated.

- d. Submittals with drawings not meeting this requirement will not be reviewed further and will be returned to the CONTRACTOR stamped "REJECTED."
- 6. factory test data certifying compliance of similar equipment from the same manufacturer with requirements of this Section
- C. The Technical Manual shall include the following documentation:
 - 1. manufacturer's 2-year warranty
 - 2. harmonic analysis report
 - 3. field test report
 - 4. programming procedure and program settings
- D. Spare Parts List
 - 1. Submit information for parts required by this Section plus any other spare parts recommended by the controller manufacturer.

PART 2 - PRODUCTS

2.01 GENERAL

- A. The CONTRACTOR shall provide a total of 3 variable frequency drives.
- B. Equipment to be operated through variable frequency drives shall include the following:

Quantity	Equipment	HP	Constant or Variable Torque (C/V)	RPM	Bypass (Y/N)	Enclosure Type
1	RASP-06-01	25			N	NEMA 3R
2	RASP-06-02,03	5			N	NEMA 3R

2.02 EQUIPMENT

- A. General
 - 1. The power supply shall be an adjustable frequency inverter designed to convert incoming 3-phase, 480-volt, 60-Hertz power to a DC voltage and then to adjustable frequency AC by use of a 3-phase inverter.
 - 2. Current-source inverters will not be accepted.
 - 3. Inverters shall be sized to match the KVA and inrush characteristics of the motors actually provided.
 - 4. The CONTRACTOR shall be responsible for matching the controller to the load (variable torque or constant torque) as well as the speed and current of the actual motor being controlled.
- B. Inverter
 - 1. The inverter shall be of a voltage-source design, producing a pulse-width-modulated type output.
 - 2. Six-step and current-source inverters will not be accepted.
 - 3. Motors:
 - a. Inverters shall be provided with 460-volt, 3-phase, 60-Hertz, squirrel-cage high-efficiency inverter duty induction motors.

- b. Motors shall be capable of operating over the range of 50-100 percent of base speed without derating or requiring any motor modifications.
 - c. Motors enclosures shall be NEMA B, TEFC (1.15 SF).
- 4. Inverters shall be capable of delivering the nameplate horsepower exclusive of service factor without the need for mandatory thermostats or feedback tachometers.
- 5. The VFD shall vary both the AC voltage and frequency simultaneously in order to operate the motor at required speeds.
- C. The minimum VFD inverter efficiency shall be 95 percent at 100 percent speed and load, and 85 percent efficiency at 50 percent speed and load.
- D. Power Outage
 - 1. The VFD shall shut down in an orderly manner when a power outage occurs on one or more phases.
 - 2. Upon restoration of power and a START signal, the motor shall restart and run at the speed corresponding to the current process input signal.
- E. The VFD shall be provided with the following features:
 - 1. inrush current adjustment between 50 and 110 percent of motor full load current (factory set at 100 percent)
 - 2. overload capability at 110 percent for 60 seconds for variable torque loads and 150 percent for constant torque loads.
 - 3. adjustable acceleration and deceleration
 - 4. input signal of 4 - 20 mA from process
 - 5. output speed signal of 4 - 20 mA; Signals other than 4 - 20 mA will not be accepted.
 - 6. Upon loss of input signal, the VFD shall operate at a preset speed.
 - 7. A minimum of 2 selectable frequency jump points in order to avoid critical resonance frequency of the driven system.
 - 8. additional devices and functions as indicated
- F. The VFD shall be provided with, as a minimum, the following protection features:
 - 1. input line protection with metal oxide varistor (MOV) and RC network
 - 2. protection against single phasing
 - 3. instantaneous overcurrent protection
 - 4. electronic overcurrent protection
 - 5. ground fault protection
 - 6. overtemperature protection for electronics
 - 7. protection against internal faults
 - 8. ability to start into rotating motor (forward or reverse rotation)
 - 9. additional protection and control as indicated and as required by the motor and driven equipment
- G. The VFD shall be designed and constructed to satisfactorily operate within the following service conditions.
 - 1. Elevation
 - a. elevation to 3300 feet

- b. For elevation greater than 3300 feet, the VFD shall be de-rated in accordance with the manufacturer's recommendation
 - 2. Ambient Temperature: 0 to 40 degrees C
 - 3. Humidity: 0 to 95 percent, non-condensing
 - 4. AC Line-Voltage Variation: plus 10 percent to minus 10 percent
 - 5. AC Line-Frequency Variation: plus-and-minus 2 Hertz
 - 6. Individual or simultaneous operation of VFDs shall not add more than 3 percent total harmonic voltage distortion and no more than 5 percent total harmonic current distortion (per IEEE 519, 1992) to the MCC.
- H. The controller supplier shall furnish (and pay for installation, conduit, conductors, and connections for equipment required outside the VFD enclosure) any necessary isolating transformers, harmonic filters, or other devices necessary for proper system operation and compliance with IEEE Standard 519, 2014 (individual or simultaneous operation of VFDs shall not add more than 3 percent total harmonic voltage distortion and no more than 5 percent total harmonic current distortion to the MCC when supplied from the specified power source. If more than one variable frequency drive is supplied from the same supply transformer secondary, provide necessary devices and circuits to prevent the operation of one drive from adversely affecting the operation of the other drives.
- I. Electrical equipment provided in addition to the adjustable frequency inverter for each drive shall include:
- 1. 2-1/2-percent (minimum) line reactor integral to the drive enclosure.
 - 2. Provide a dV/dT filter device at the motor or VFD output per the manufacturer's recommendation. Submit documentation demonstrating where such devices are required, along with mounting and cabling requirements.
 - 3. fused 480-to-120-volt control transformer to provide system control power for the logic and pilot lamps.
 - 4. Provide an input circuit breaker.
 - 5. Heaters
 - a. Provide overload heaters with auxiliary contacts in order to protect the motors in both VFD and bypass modes.
 - b. Refer to the Elementary Schematics indicated on the Drawings.
 - c. The heaters shall be sized for the motor actually being provided.
- J. Inverter Signal Circuits
- 1. The inverter signal circuits shall be isolated from the power circuits and shall be designed to accept an isolated 4-20 mA signal in the automatic mode of operation.
 - 2. The inverter shall follow the setting of a remote or local potentiometer control while in the manual mode.
 - 3. Refer to the Elementary Schematic indicated on the Drawings for speed control and START/STOP methods.
 - 4. Access to set-up and protective adjustments shall be protected by key-lockout.
 - 5. The following operator monitoring and control devices for the inverter shall be provided on the face of the VFD enclosure, either as discrete devices or as part of a multi-function microprocessor-based keypad access device:
 - a. AUTO/HAND selection from a remote logic relay or switch

- b. While in AUTO, the inverter shall operate from the remote 4-20 mA input, where applicable, and while in HAND control shall operate from a local or remote manually operated speed potentiometer; speed pot ratings shall be coordinated with the supplier of the Local Control Station.
- c. speed indicator calibrated in percent speed
- d. inverter fault trip pilot light and output alarm contacts
- e. trip reset pushbutton
- f. RUN and OFF indicating lights
- g. Provide other controls and readouts normally furnished as standard equipment, or as otherwise indicated on the Elementary Schematics indicated on the Drawings.
- K. Properly identified screw type terminal boards shall be provided for interconnection to remote controls and instrumentation
- L. Pilot devices, control relays, time delay relays, elapsed time meters, and indicators provided as a part of the VFD equipment package shall meet the applicable requirements of Section 16485 – Industrial Control Panels.

2.03 SPARE PARTS

- A. The CONTRACTOR shall furnish the spare parts listed below, suitably packaged and labeled with the corresponding equipment number.
- B. Modified Parts
 - 1. At any time prior to Substantial Completion, the CONTRACTOR shall notify the ENGINEER in writing about any manufacturer's modification of spare part numbers, interchangeabilities, or model changes.
 - 2. If the ENGINEER determines that the modified parts no longer apply to the equipment provided, the CONTRACTOR shall furnish other applicable parts as part of the WORK.
- C. The following spare parts shall be furnished:
 - 1. Provide one set of spare power fuses of each form, voltage, and current rating.
 - 2. Provide 10 spare control and power fuses of each type and rating.
 - 3. Provide 10 panel lamps of each type (form, voltage, and current rating).
 - 4. Provide one of each type of circuit board, as applicable:
 - a. control board
 - b. power board
 - c. diode bridge
 - d. transistor module
 - 5. Provide one of each size and type power diode and transistor.
 - 6. Provide one set of any special tools required for maintenance of the VFD units

2.04 Manufacturers, or approved equal

- A. EATON – SVX9000 Series
- B. ALLEN BRADLEY – PowerFlex 573

PART 3 - EXECUTION

3.01 MANUFACTURER'S SERVICES

- A. General

1. An authorized service representative of the manufacturer shall be present at the Site for 3 Days to furnish the services listed below.
 2. For the purpose of this Paragraph, a Day is defined as an 8-hour period excluding travel time.
- B. The authorized service representative shall supervise the following and shall certify that the equipment and controls have been properly installed, aligned, and readied for operation:
1. installation of the equipment
 2. inspection, checking, and adjusting the equipment
 3. startup and field testing for proper operation
 4. performing field adjustments such that the equipment installation and operation comply with requirements
- C. Instruction of OWNER's Personnel
1. The authorized representative shall instruct the OWNER's personnel in the operation and maintenance of the equipment, including step-by-step troubleshooting with test equipment.
 2. The instruction shall be specific to the VFD models provided.
 3. Training shall be scheduled a minimum of 3 weeks in advance of the first session.
 4. Training shall include individual sessions for 4 shifts of plant personnel.
 5. Proposed training materials shall be submitted for review, and comments shall be incorporated.
 6. Training materials shall remain with the trainees.
 7. The OWNER may videotape the training for later use with the OWNER's personnel.

3.02 INSTALLATION

- A. Conduit stub-ups for interconnected cables and remote cables shall be located and terminated in accordance with the drive manufacturer's recommendations.
- B. Programming
1. The CONTRACTOR shall perform programming of drive parameters required for proper operation of the VFDs included in this project.
 2. Submit records of programming data in the equipment Technical Manual, including setup and protective settings.

3.03 FIELD TESTING

- A. Testing, checkout, and startup of the VFD equipment in the field shall be performed under the technical direction of the manufacturer's service engineer.
- B. Under no circumstances shall any portion of the drive system be energized without authorization from the manufacturer's representative.
- C. Verify proper operation of control logic in every mode of control.

END OF SECTION

SECTION 16431
PROTECTIVE DEVICE STUDIES

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. The CONTRACTOR shall perform the indicated short circuit and protective device studies for the electrical power system in accordance with the Contract Documents.
- B. The WORK of this Section shall include protection studies for motors with solid state overload and overcurrent protection devices.
- C. It is the responsibility of the CONTRACTOR to obtain the information required from the electric utility and appropriate vendors.

1.02 QUALIFICATIONS

- A. Short circuit studies, protective device evaluation studies, arc-flash hazard analysis studies, and protective device coordination studies shall be performed by a manufacturer who has been regularly engaged in short circuit and protective device coordination services for a period of at least 10 years.
- B. The indicated studies shall be signed by the professional electrical engineer, registered in the State of California, responsible for the studies.
- C. The studies shall utilize computer programs with proven reliability and accuracy for performing 3-phase fault-duty calculations.

1.03 SUBMITTALS

- A. The indicated studies shall be submitted and approved by the ENGINEER prior to final approval of the distribution equipment Shop Drawings and release of equipment for manufacture.
- B. An initial short circuit study shall be submitted and reviewed before the ENGINEER will approve the Shop Drawings for medium-voltage switchgear, transformers, or 480-volt distribution equipment.
- C. Submit an initial protective device coordination study shall be submitted with 90 days after the approval of the initial short circuit study.
- D. The short circuit, arc-flash hazard analysis, and protective device coordination studies shall be updated prior to Project Substantial Completion; utilize characteristics of as-installed equipment and materials.
- E. The adequacy of the equipment "withstand" and interruption ratings shall be approved by the ENGINEER.

1.04 MANUFACTURERS' SERVICES

- A. The low-voltage switchgear manufacturer shall furnish the services of a qualified field engineer and necessary tools and equipment in order to test, calibrate, and adjust the protective relays and circuit breaker trip devices as recommended in the power system coordination study.
- B. The motor control center manufacturer shall furnish the services of a qualified field engineer to calibrate the MCPs as recommended in the power system study.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.01 GENERAL

- A. The studies shall include development of single-line and impedance diagrams of the power system.
- B. The diagrams shall identify components considered in the study and the ratings of power devices, including transformers, circuit breakers, relays, fuses, busses, and cables.
- C. The resistances and reactance's of cables shall be identified in the impedance diagram.
- D. The studies shall contain written data from the electric utility company regarding maximum available short circuit current, voltage, and X/R ratio of the utility power system.
- E. The studies shall include every protective device and feeder included within the WORK.
- F. The first upstream overcurrent device outside the WORK shall be used as a fixed reference.
- G. The studies shall include all portions of the electrical distribution system for normal and standby power sources down to and including the 480-volt distribution system.

3.02 SHORT CIRCUIT STUDY

- A. The short circuit study shall be performed with the aid of a digital computer program, and shall be in accordance with the following Standards:

ANSI/IEEE 141	Recommended Practice for Electrical Power Distribution for Industrial Plants
ANSI/IEEE 242	Recommended Practice for Protection, and Coordination of Industrial, and Commercial Power Systems
ANSI/IEEE C 37.010	Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis
ANSI/IEEE C 37.13	Low-Voltage AC Power Circuit Breakers Used in Enclosures

3.03 PROTECTIVE DEVICE EVALUATION STUDY

- A. A protective device evaluation study shall be performed in order to determine the adequacy of circuit breakers, molded case switches, and fuses.
- B. Any problem areas or inadequacies in the equipment due to prospective short-circuit currents shall be promptly brought to the attention of the ENGINEER.
- C. Do not utilize series-rated circuit breakers to meet short circuit requirements for this project.
- D. Devices shall be fully rated to withstand available fault currents.

3.04 PROTECTIVE DEVICE EVALUATION STUDY

- A. A protective device coordination study shall be performed in order to develop the necessary calculations to select power fuse ratings, protective relay characteristics and settings, ratios and characteristics of associated current transformers, and low-voltage breaker trip characteristics and settings.
- B. Any problem areas or inadequacies in the equipment due to prospective short-circuit currents shall be promptly brought to the ENGINEER's attention.

3.05 TIME/CURRENT COORDINATION CURVES

- A. As a minimum, the time/current coordination curves for the power distribution system shall include the following items plotted on 5-cycle log-log graph paper:
1. time/current curves for each protective relay, circuit breaker, or fuse demonstrating graphically that the settings will provide protection and selectivity within industry standards
 2. Each curve shall be identified, and tap and time dial settings shall be specified.
 3. Provide individual curves for each feeder unless identical to others.
 4. Selectivity
 - a. Time/current curves for each device shall be positioned to provide the maximum selectivity to minimize system disturbances during fault clearing.
 - b. Where selectivity cannot be achieved, the ENGINEER shall be notified as to the cause.
 - c. Recommendations shall be included for alternate methods that would improve selectivity.
 5. time/current curves and points for cable and equipment damage.
 6. circuit interrupting device operating and interrupting times
 7. Indicate maximum fault values on the graph.
 8. sketch of bus and breaker arrangement
 9. magnetizing inrush points of transformers
 10. thermal limits of dry-type and liquid-insulated transformers (ANSI damage curve)
 11. Every restriction of the ANSI and National Electrical Code shall be followed, and proper coordination intervals and separation of characteristics curves shall be maintained.

3.06 ARC FLASH STUDY

- A. An arc flash study shall be performed with the aid of a digital computer program in order to determine the "Arc Flash Protection Boundary" and "Personal Protective Equipment" (PPE) levels for applicable electrical distribution equipment, stand-alone disconnects, starters, and VFDs in the power distribution system.
- B. The arc flash study shall be performed in conjunction with short circuit calculations and protective device coordination.
- C. The arc flash study shall be in accordance with the latest version of the following Standards:
1. NFPA 70E Standard for Electrical Safety Requirements for Employee Workplaces
 2. IEEE 1584 IEEE guide for performing Arc Flash Hazard Calculations
 3. OSHA (29 CFR PART 1910) Occupational Safety and Health Standards for General Industry
 4. ANSI Z535.4 Product Safety Signs and Labels
- D. The recommended values for the "Arc Flash Protection Boundary" and PPE levels, based on the arc flash study results, shall be tabulated in the study.
- E. Labeling
1. The digital computer program shall provide the "Arc Flash Protection Boundary" and PPE values in a format that can be directly printed on to labels.
 2. The CONTRACTOR shall provide these labels in accordance with Section 16050 – General Electrical Work.

3.07 FINAL SUMMARY REPORT

- A. Summarize the results of the indicated power system studies in a final report.
- B. The report shall include the following items:
 - 1. single-line diagram
 - 2. impedance diagram
 - 3. tabulation of all protective devices identified on the single line diagram
 - 4. time/current coordination curves
 - 5. specific recommendations, if any
 - 6. test instrumentation, condition, and connections, as applicable, for each study
 - 7. computerized fault current calculations
 - 8. any suggested changes to the protection scheme or equipment selection that will result in improved system reliability and safety
 - 9. recommendations to minimize the arc flash energy
- C. The report shall include information concerning the computer program used for the study, as well as a general discussion of the procedure, items, and data considered in the preparation of the study.
- D. Submit 4 bound copies and PDF including all protective device study data files of the report to the ENGINEER.

3.08 PROTECTIVE DEVICE TESTING, CALIBRATION, AND ADJUSTMENT

- A. Test, calibrate, and adjust the protective relays and circuit breaker trip devices in accordance with the recommendations in the power system coordination study.
- B. Calibrate the MCPs as in accordance with the recommendations in the power system study.
- C. Adjustments shall be made prior to energizing any electrical equipment.

END OF SECTION

SECTION 16450
GROUNDING

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. Provide the electrical grounding system, complete and operable, as indicated in accordance with the Contract Documents.
- B. The requirements of Section 16050 – General Electrical Work, apply to this Section.
- C. Single Manufacturer
 - 1. Like products shall be the end product of one manufacturer in order to achieve standardization of appearance, operation, maintenance, spare parts, and manufacturer's services.

1.02 SUBMITTALS

- A. Furnish submittals in accordance with the requirements of Section 01330 – Submittal Procedures and Section 16050 – General Electrical Work.
- B. Shop Drawings
 - 1. Submit manufacturer's product information for connectors, clamps, and all grounding system components, showing compliance with the requirements of this Section.

PART 2 - PRODUCTS

2.01 EQUIPMENT

- A. Components of the grounding electrode system shall be manufactured in accordance with UL 467 - Standard for Safety Grounding and Bonding Equipment, and shall conform to the applicable requirements of National Electrical Code Article 250 and local codes.
- B. Grounding System
 - 1. Grounding loop conductors shall be bare annealed copper conductors.
 - 2. Conductors shall be No. 4/0 unless indicated otherwise.
 - 3. Ground Rods
 - a. Unless indicated otherwise, provide ground rods minimum of 3/4 inch in diameter, 10 feet long, and with a uniform covering of electrolytic copper metallicity bonded to a rigid steel core.
 - b. Provide corrosion-resistant copper-to-steel bond.
 - c. The rods shall conform to UL 467.
 - d. The rods shall be of the sectional type, joined by threaded copper alloy couplings.
 - 4. Buried, concrete-encased, or otherwise inaccessible cable-to-cable and cable-to-ground rod connections using exothermic welds.
 - a. Manufacturer, or Equal
 - **Cadweld**
 - **Thermoweld**
 - 5. Exposed Connectors

- a. Exposed grounding connectors shall be of the compression type (connector-to-cable), constructed of high-copper alloy, and manufactured specifically for the particular grounding application.
 - b. Manufacturer, or Equal
 - **Burndy**
 - **O.Z. Gedney**
6. Use grounding clamps to bond each separately-derived system to the grounding electrode conductors.
7. Equipment Grounding Circuit Conductors
- a. The conductors shall be the same type and insulation as the load circuit conductors.
 - b. The minimum size shall be as indicated. Where not indicated, sizes shall conform to Table 250.122 of the National Electrical Code.
 - c. Metallic conduit systems shall have an equipment grounding wires as well as being equipment grounding conductors themselves.
8. Grounding Materials Manufacturer, or Equal
- a. **Copperweld**
 - b. **Thermoweld**
 - c. **OZ Gedney**

PART 3 - EXECUTION

3.01 PREPARATION

- A. Provide a separate grounding conductor, securely grounded in each raceway independent of raceway material.
- B. Provide a separate grounding conductor for each motor and connect at motor box. Provide a supplemental ground connection for motor shaft grounding rings, where applicable.
- C. Do not use bolts for securing the motor box to the frame or the cover for grounding connectors.
- D. Sizes shall be as indicated on the Conduit Schedule and in accordance with NEC Article 250.
- E. Route the conductors inside the raceway.
- F. Provide a grounding-type bushing for secondary feeder conduits that originate from the secondary section of each MCC section, switchboard, or panelboard.
- G. Individually bond the raceway to the ground bus in the secondary section.
- H. Provide a green insulated wire as grounding jumper from the ground screw to a box grounding screw, and, for grounding type devices, to the equipment grounding conductor.
- I. Provide a separate grounding conductor in each individual raceway for parallel feeders. Connect the parallel ground conductors together at each end of the parallel run, as required by the NEC.
- J. Interconnect the secondary switchgear MCC or panelboard neutral bus to the ground bus in the secondary switchgear compartment only at the service entrance point. For wye connected, 3 phase, separately derived systems with 3 wire distribution, connect the transformer neutral to the grounding electrode system at the transformer. Connections shall be in accordance with the NEC.
- K. Provide the duct bank ground system as indicated, including trenching, splices, ground rods, and connections to equipment and structures.

- L. Measure ground impedance in accordance with IEEE STD 81 after installation but before connecting the electrode to the remaining grounding system. Provide additional grounding system testing in accordance with Section 16950 – Electrical Tests.
- M. Low Voltage Grounded System (600V or less)
1. A low-voltage grounded system is defined as a system where the local power supply is a transformer, with the transformer secondary grounded.
 2. Grounding system connections for a premises-wired system supplied by a grounded AC service shall be provided with a grounding electrode connector connected to the grounded service conductor at each service, in accordance with the NEC.
 3. The grounded circuit conductor shall not be used for grounding non-current-carrying parts of equipment, raceways, and other enclosures except where specifically listed and permitted by the NEC.
- N. Embedded Ground Connections
1. Underground and grounding connections embedded in concrete shall be UL-listed ground grid connectors.
 2. The connection shall be made in accordance with the manufacturer's instructions.
 3. Do not conceal or cover ground connections until the ENGINEER or an authorized representative has established that every grounding connection conforms to the requirements of the Contract Documents and has given the CONTRACTOR written confirmation.
- O. Ground Ring
1. Furnish trenching and materials as necessary to install the ground ring as indicated.
 2. The bonding conductor shall be in direct contact with the earth and of the indicated size.
 3. Provide a minimum burial depth of 36 inches or as indicated on the Drawings, whichever is greater.
 4. Re-compact disturbed soils to their original density in 6-inch lifts.
- P. Duct Bank Ground
1. Embed a grounding conductor in every duct bank as indicated. The ground conductor shall be terminated at the ground grid at each end of the duct bank. Where no ground grid is installed, terminate at a suitable grounding electrode conductor near the end of the duct bank in accordance with the NEC.
- Q. Ground Rods
1. Provide ground rods at the indicated locations.
 2. A single electrode that does not have resistance-to-ground of 5 ohms or less shall be augmented by additional electrodes to obtain this value.
 3. Take the resistance-to-ground measurement during dry weather, a minimum of 48 hours after a rainfall.
 4. Rods forming an individual ground array shall be equal in length.
- R. Instrumentation Shield Grounding
1. Shielded instrumentation cable shall have its shield grounded at one end only unless the approved Shop Drawings indicate that the shield will be grounded at both ends.
 2. The grounding point shall be at the control panel or at the receiving end of the signal carried by the cable.

3. The termination of the shield drain wire shall be on its own terminal screw.
4. Jumper together the terminal screws, using manufactured terminal block jumpers or a No. 14 green insulated conductor.
5. Connect the ground bus via a green No. 12 conductor to the main ground bus for the panel.

END OF SECTION

SECTION 16460

ELECTRIC MOTORS

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. The CONTRACTOR shall provide electric motors, accessories, and appurtenances complete and operable, in conformance to the Contract Documents.
- B. The provisions of this Section apply to low voltage 3 phase, AC squirrel cage induction motors throughout the Contract Documents, except as indicated otherwise.
- C. The CONTRACTOR shall assign to the equipment supplier the responsibility to select suitable electric motors for the equipment. The choice of motor manufacturer shall be subject to review by the ENGINEER. Such review will consider future availability of replacement parts and compatibility with driven equipment

1.02 RELATED WORK

- | | |
|------------------|-----------------------------------|
| A. Section 01330 | Submittal Procedures |
| B. Section 16050 | General Electrical Work |
| C. Section 16155 | Low-Voltage Motor Control Centers |
| D. Section 16260 | Variable Frequency Drive Units |

1.03 REGULATORY AGENCIES AND STANDARDS

- A. Regulatory Agencies: Testing shall conform to the latest provisions of the following agencies:
1. NEC (NFPA 70) National Electrical Code: 2020 Edition
- B. Standards: Where referenced in these specifications or on the drawings, the publications and standards of the following organizations apply:
1. NEMA National Electrical Manufacturers Association
- a. NEMA MG-1, Motor and Generator Standards

1.04 SUBMITTALS

- A. Furnish submittals in accordance with Section 01330 - Submittal Procedures.
- B. Complete motor data shall be submitted with the driven machinery Shop Drawings. Motor data shall include:
1. Machine name and specification number of driven machines
 2. Motor manufacturer
 3. Motor type or model and dimension drawing. Include motor weight.
 4. Nominal horsepower
 5. NEMA design
 6. Enclosure
 7. Frame size
 8. Winding insulation class and temperature rise class
 9. Voltage, phase, and frequency ratings
 10. Service factor
 11. Full load current at rated horsepower for application voltage
 12. Full load speed

13. Guaranteed minimum full load efficiency and nominal efficiencies at 1/2 and 3/4 load.
 14. Type of thermal protection or overtemperature protection, where included
 15. Wiring diagram for devices such as motor leak detection, temperature, or zero speed switches, as applicable
 16. Bearing data. Include recommendation for lubricants of required type bearings.
 17. If utilized with a variable frequency controller, verify motor is inverter duty type. Include minimum speed at which motor may be operated for the driven machinery. Provide shaft grounding details and information. Provide insulated bearing details and information.
 18. Power factor at 1/2, 3/4 and full load.
 19. Recommended size for power factor correction capacitors to improve power factor to 0.95 percent lagging when operated at full load.
- C. If water cooling is required for motor thrust bearings, the Shop Drawing submittals shall indicate this requirement.

1.05 FACILITY OPERATION AND MAINTENANCE MANUALS

- A. Submit complete operation and maintenance manual in accordance with the requirements of Section 01730 – Operation and Maintenance Information.

PART 2 - MATERIALS

2.01 GENERAL

- A. Electric motors driving identical machines shall be identical.
- B. Electric motors shall comply with NEMA MG-1 - Motor and Generator. Motors used with adjustable frequency drives shall comply with NEMA MG-1, Part 31, and shall be clearly identified as "Inverter Duty."
- C. Maximum motor loading shall be equal to nameplate horsepower rating or less, exclusive of service factor and be verifiable from the submittal data of the driven machinery.
- D. Electric motors shall be NEMA Design B unless otherwise indicated. Starting torque or breakdown torque be less than the value in NEMA MG 1 shall not be permitted. Motors shall be suitable for the indicated starting method.
- E. Motor Voltage Ratings
1. Low voltage motors shall have voltage ratings in accordance with the following, unless otherwise indicated:
 - a. Motors below 1/2 HP shall be rated 115 volts, single phase, 60 Hz. Dual voltage motors rated 115/230 volts, 115/208 volts, or 120-240 volts are acceptable, provided leads are brought out to the conduit box.
 - b. Motors 1/2 HP and larger shall be rated 460 volts, 3 phase, 60 Hz. Dual voltage motors rated 230/460 volts or 208/230/460 volts are acceptable, provided every lead is brought out to the conduit box.
- F. Insulation
1. Three phase motors shall be provided with Class F insulation, rated to operate at a maximum ambient temperature of 40 degrees C and at the altitudes where the motors will be installed and operated, without exceeding Class B temperature rise limits stated in NEMA MG 1-12.44.
 2. Single phase motors shall have Class F insulation with temperature rise not to exceed the insulation class.

3. Motors to be operated from adjustable frequency drives shall be provided with insulation systems to withstand 1600-volt spikes, with dV/dT as defined in NEMA MG 1-31.
 4. The adjustable frequency drive manufacturer shall coordinate with the motor manufacturer to determine when additional dV/dT protection is required. Where required, it shall be furnished and installed as per the manufacturer's written instructions.
- G. Motors (Non-hazardous locations)
1. 50 HP or smaller shall be totally enclosed, fan cooled (TEFC) with a Service Factor of 1.15 unless otherwise indicated.
- H. Motors (hazardous locations)
1. Motors for use in hazardous locations shall have enclosures suitable for the classification indicated. Such motors shall be U.L. listed and be stamped as such.
- I. Motors installed outdoors or where indicated shall be provided with 120-volt AC space heaters, wired to a terminal strip in a low voltage motor junction box. If provided by the manufacturer when not specified, the manufacturer shall not require that they be connected or the CONTRACTOR shall connect them at no extra cost to the OWNER, in order to keep the warranty in force.
- J. NEMA Premium Efficiency Motors
1. Motors with a nameplate rating of 1 HP and larger shall be NEMA premium efficient units. Motors shall be stamped with the efficiency on the nameplate with the caption "NEMA Nominal Efficiency" or "NEMA Nom. Eff." Such motors shall have efficiencies determined by the test as set forth in ANSI/IEEE 112 - Standard Test Procedure for Polyphase Induction Motors and Generators, Method B.
 2. Efficiency: Nominal efficiency and minimum efficiency shall be defined in accordance with the following tables. Both efficiencies shall be included in the Shop Drawing submittal.

Source: NEMA MG1 - 2016, Table 12-12

TOTALLY ENCLOSED - FAN COOLED (TEFC)						
FULL-LOAD EFFICIENCIES OF NEMA PREMIUM EFFICIENCY MOTORS RATED 600 VOLTS OR LESS						
	2 POLE		4 POLE		6 POLE	
HP	Nom. Effic.	Min. Effic.	Nom. Effic.	Min. Effic.	Nom. Effic.	Min. Effic.
1	77.0	74.0	85.5	82.5	82.5	80.0
1.5	84.0	81.5	86.5	84.0	87.5	85.5
2	85.5	82.5	86.5	84.0	88.5	86.5
3	86.5	84.0	89.5	87.5	89.5	87.5
5	88.5	86.5	89.5	87.5	89.5	87.5
7.5	89.5	87.5	91.7	90.2	91.0	89.5
10	90.2	88.5	91.7	90.2	91.0	89.5
15	91.0	89.5	92.4	91.0	91.7	90.2
20	91.0	89.5	93.0	91.7	91.7	90.2
25	91.7	90.2	93.6	92.4	93.0	91.7
30	91.7	90.2	93.6	92.4	93.0	91.7
40	92.4	91.0	94.1	93.0	94.1	93.0
50	93.0	91.7	94.5	93.6	94.1	93.0
60	93.6	92.4	95.0	94.1	94.5	93.6
75	93.6	92.4	95.4	94.5	94.5	93.6
100	94.1	93.0	95.4	94.5	95.0	94.1
125	95.0	94.1	95.4	94.5	95.0	94.1
150	95.0	94.1	95.8	95.0	95.8	95.0
200	95.4	94.5	96.2	95.4	95.8	95.0
250	95.8	95.0	96.2	95.4	95.8	95.0
300	95.8	95.0	96.2	95.4	95.8	95.0
350	95.8	95.0	96.2	95.4	95.8	95.0
400	95.8	95.0	96.2	95.4	--	--
450	95.8	95.0	96.2	95.4	--	--
500	95.8	95.0	96.2	95.4	--	--

Source: NEMA MG1 - 2016, Table 12-12

K. Two speed motors shall be of the 2-winding type.

L. Motor Capacity

1. Motor size shall be de-rated from nameplate values as follows:

a. Ambient Temperature

- For ambient temperatures up to but not exceeding 40 degrees C, no derating is required.
- For ambient temperatures exceeding 40 degrees but less than 50 degrees C, de-rate nameplate HP ratings to 85 percent.

b. Site Altitude: No derating is required for altitudes less than 3300 feet (1000 meters). Higher altitudes require the following derating factors:

Altitude	Derating Factor
3,300 to 5,000 ft	97 percent
5,001 to 6,600 ft	94 percent
6,601 to 8,300 ft	91 percent
8,301 to 9,900 ft	88 percent
9,901 to 11,500 ft	85 percent

2. Increased circuit breaker, magnetic starter, and conductor and conduit capacities required for motors larger than the indicated sizes shall be provided as part of the WORK.

2.02 ACCESSORY REQUIREMENTS

- A. General: Horizontal motors 3 HP and larger and every vertical motor shall have split-type cast metal conduit boxes. Motors shall be provided with oversized conduit boxes. Where conduit sizes indicated do not match the motor terminal box, the CONTRACTOR shall provide means to accommodate the motor requirements. Motor boxes other than open drip-proof shall be gasketed.
- B. Lifting Devices: Motors weighing 265lb (120Kg) or more shall have suitable lifting eyes for installation and removal.
- C. Special Requirements: The CONTRACTOR shall refer to individual equipment specifications for special requirements such as motor winding thermal protection or multi-speed windings.
- D. Grounding Lugs: Provide motor grounding lug suitable to terminate ground wire, sized as indicated.
- E. Nameplate: Motors shall be fitted with permanent stainless-steel nameplates indelibly stamped or engraved with NEMA Standard motor data, in conformance with NEMA MG-1-10.40. Inverter duty motors shall be clearly identified as such.
- F. Where motors are indicated by elementary schematics or specifications to have zero speed switches, the switches shall be factory mounted integral to the motors. Switches shall close the contacts when the motor is at zero speed.

- G. Inverter duty motors shall be provided with shaft grounding rings. Rings shall be factory installed, and shall be manufactured by **Aegis**, or equal. The motor warranty shall include coverage against VFD-induced bearing damage or failure.

2.03 MOTOR THERMAL PROTECTION

- A. Single Phase Motors: Single phase 120-volt motors shall have integral thermal overload protection or shall be inherently current limited.
- B. Thermostats: Where indicated or specified, winding thermostats shall be snap action, bi-metallic, temperature-actuated switch. Thermostats shall be provided with one normally closed contact. The thermostat switch point shall be pre-calibrated by the manufacturer. All inverter duty motors shall be provided with winding thermostats, unless RTDs are specified. All explosion-proof motors shall be provided with winding thermostats.

2.04 MOTOR BEARINGS

A. Vertical Motors

- 1. Provide bearings of the type and size required to meet the thrust loading requirements with a rated B-10 life of 100,000 hours as defined by the Anti-Friction Bearing Manufacturers Association (AFBMA).
- 2. Bearings for motors 75 HP and larger shall be oil lubricated and contained in an oil reservoir with oil sight level gage and oil fill and drain openings with plugs.
- 3. Equip grease lubricated bearings with fittings in each bearing housing. Fittings shall be accessible without removals of any covers or guards. Provide drains to prevent over lubrication.

B. Horizontal Motors:

- 1. General: Equip motors larger than one (1) HP with end single shielded bearings of either the anti-friction or sleeve type with a rated B-10 life of 100,000 hours as defined by the AFBMA.
- 2. Anti-Friction Type: Grease lubricated type with sealed end caps to prevent grease from migrating to the bearing exterior. Provide with an excess-grease reservoir located outboard of the bearing and provisions for purging old grease.
- 3. Sleeve Type: Oil lubricated type contained in an oil reservoir with oil sight level gage and oil fill and drain openings with plugs. Provide bearings with shaft seals and pressure-equalizing vents to prevent oil from migrating to the motor windings.

- C. Inverter Duty Motors: Provide an insulated bearing to prevent circulating bearing currents.

2.05 CONNECTION BOXES

- A. Provide motors with NEMA MG-1 type I connection boxes made of fabricated steel or cast-iron construction compatible with the motor specified. Provide motors larger than 150 Hp with NEMA MG-1 type II connection boxes. Provide boxes with gaskets between the box and motor and between the box and cover. Boxes shall be capable of rotation in 90° increments. Align boxes for bottom conduit entry.
- B. Provide an auxiliary terminal box for terminating auxiliary and protective devices lead wires.

2.06 MANUFACTURERS, OR EQUAL

A. U.S. Motors/Nidec

B. Baldor

C. WEG

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Motor installation shall be performed in accordance with the motor manufacturer's written recommendations and the written requirements of the manufacturer of the driven equipment. Shaft grounding devices shall be connected to the grounding system in accordance with the manufacturer's recommendations.
- B. Related electrical WORK involving connections, controls, switches, and disconnects shall be performed in accordance with the applicable sections of Division 16.

3.02 STORAGE

- A. Protect motors from exposure of elements for which they are not designed. Install and energize temporary electrical service to motors with electrical heaters.
- B. Unless protected by manufacturer's packing, upon delivery, carefully wrap each motor in three layers of 8 mil minimum polyethylene. Secure the wrap with adhesive tape to minimize the entrance of moisture. For base mounted motors, wrap the entire assembly.

3.03 FACTORY TESTING

- A. Motors rated 100 HP and larger shall be factory tested in conformance with IEEE 112, IEEE 43 - Recommended Practice for Testing Resistance of Rotating Machinery, and NEMA MG-2. Except where specific testing or witnessed shop tests are required by the specifications for driven equipment, factory test reports may be copies of routine test reports of electrically duplicate motors. Test report shall indicate test procedure and instrumentation used to measure and record data. Test report shall be certified by the motor manufacturer's test personnel and be submitted to the ENGINEER.

3.04 FIELD TESTING

- A. The CONTRACTOR shall perform the following field tests (see also Section 16950 – Electrical Testing):
 - 1. Inspect each motor installation for any deviation from rated voltage, phase, frequency, and improper installation.
 - 2. Visually check for proper phase and ground connections. Verify that multi-voltage motors are connected for proper voltage. Verify shaft grounding devices are properly grounded.
 - 3. Check winding and bearing temperature detectors and space heaters for functional operation.
 - 4. Test for proper rotation prior to connection to the driven equipment.
 - 5. Visually check that motor overload heaters are properly sized and that MCP breaker settings are correct for the motor installed.
 - 6. Test insulation (megger test) of new and re-used motors in accordance with NEMA MG-1. Test voltage shall be 1000 VAC plus twice the rated voltage of the motor.

END OF SECTION

**SECTION 16485
INDUSTRIAL CONTROL PANELS**

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. The CONTRACTOR shall provide complete industrial control panels and/or local control stations as indicated herein or in other Sections of the Specifications. The stations shall be designed to provide the sequence of operation in Section 17010 – Process Control and Instrumentation Systems and the P&ID Drawings.
- B. This section also specifies miscellaneous electrical devices used throughout this project. These devices are not limited to use within industrial control panels or local control stations.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. Industrial control panels and/or local control stations shall comply with the requirements of NEC (including Article 409), NEMA, and UL.

1.03 SUBMITTALS

- A. Furnish Shop Drawings in accordance with Sections 01330 – Submittal Procedures and 16050 – General Electrical Work.
 - 1. Ladder diagrams and written descriptions explaining ladder diagram operation and system operation.
 - 2. Include catalog cuts of control equipment including enclosures, overcurrent devices, relays, pilot devices, terminations, and wire troughs.

PART 2 - PRODUCTS

2.01 GENERAL

- A. The CONTRACTOR shall provide the equipment, panels and stations to satisfy the functional requirements in the relevant mechanical equipment and Instrumentation and Control specifications and the Electrical Elementary Schematics. Each panel and station shall be fabricated with UL labeled components. Equipment not specifically indicated as being WORK of other Sections shall be provided under this Section. All equipment, panels and stations shall be wired under this Section.
- B. The controls shall be 120 V maximum. Where the electrical power supply is 240 V, single phase or 480 V, 3 phase, the station shall be provided with a fused control power transformer. Control conductors shall be provided in accordance with Section 16120 – Wires and Cabling.
- C. Each panel and/or station shall be provided with identified terminal strips for the connection of external conductors. The CONTRACTOR shall provide sufficient terminal blocks to connect 25 percent additional conductors for future use. Termination points shall be identified in accordance with Shop Drawings. The panels and/or stations shall be the source of power for all 120 VAC solenoid valves interconnected with the panels and/or stations. Equipment associated with the panels and/or stations shall be ready for service after connection of conductors to equipment, controls, panels and/or stations.
- D. Wiring to door-mounted devices shall be extra flexible and anchored to doors using wire anchors cemented in place. Exposed terminals of door-mounted devices shall be guarded to prevent accidental personnel contact with energized terminals.
- E. Enclosures
 - 1. In finished rooms, enclosures shall be NEMA 12 steel enclosures painted with ANSI 61 exterior and white interior.

2. In all other non-hazardous areas, enclosures shall be NEMA 4X stainless steel with brushed finish. Where possible, penetrations shall be made in such a manner to maintain the NEMA 4X rating. If this is not possible, the penetrations shall be made in such a manner to minimize entry of foreign materials into the enclosure, subject to approval by the ENGINEER.
 3. In hazardous areas, enclosures shall be cast aluminum NEMA 7 and shall be UL listed for use in hazardous or classified locations.
 4. In chemical areas for alum, sodium hypochlorite, etc., NEMA 4X fiberglass enclosures shall be used.
 5. Enclosures shall be freestanding, pedestal-mounted, or equipment skid-mounted, as indicated. Internal control components shall be mounted on a removable mounting pan. Mounting pan shall be finished white.
- F. Disconnect Switches
1. Heavy duty, fusible, single throw switches shall be rated not less than 65 KAIC at 480 VAC.
 2. Horsepower rated
 3. UL listed
 4. Padlockable in "Off" position and door interlock
 5. Enclosure per area classification in Section 16050 – General Electrical Work.
 6. 480 V, 3-phase, 3-pole (6-pole when used with 2-speed motor).
 7. Auxiliary control contact as applicable and where indicated.
 8. As manufactured by **GE, Eaton Electrical, Square D**, or equal.
- G. Identification of panel-mounted devices, conductors, and electrical components shall be in accordance with Section 16050 – General Electrical Work.
- H. Panel-mounted devices shall be mounted a minimum of 3-feet above finished floor elevation, but not higher than 6'-6" above finished floor, unless noted otherwise.

2.02 PANEL/STATION COMPONENTS

- A. Pushbuttons, selector switches, and pilot lights shall be the heavy-duty, oil-tight type, sized to 30-mm. Miniature style devices are not acceptable. Devices shall be as manufactured by **Allen Bradley, EATON, Square-D**, or equal.
1. Lens colors shall be RED for "run"; GREEN for "ready"; and AMBER for "alarm".
 2. Pilot lights shall be full voltage, push-to-test LED cluster type.
 3. Provide hazardous location type pilot devices in classified locations.
- B. Relays shall be 3 PDT with 10 amp contacts, plug-in type with indicating light, rectangular blades and provided with sockets for screw-type termination and hold-down clips. Relays shall be as manufactured by **Square-D, Potter Brumfield**, or equal.
- C. Elapsed time meters shall be non-resettable type, read to a maximum of 99999.9 hours and shall be as manufactured by **GE, EATON**, or equal.
- D. Magnetic starters shall be:
1. NEMA rated, Size 1 minimum. IEC or dual NEMA/IEC rated type are not acceptable.
 2. FVNR type unless indicated otherwise.
 3. Combination starters with magnetic only instantaneous trip circuit breakers such as **EATON HMCP, SE GV5PB**, or equal. Breakers shall be rated 65 KIAC minimum.

- 4. Control transformers shall be provided with primary and secondary fuses, 120 V maximum control voltage. VA rating of transformer shall be based on devices on the control schematic.
- E. Terminal strips shall be provided for every panel and shall be the flanged fork or ring lug type suitable for No. 12 AWG stranded wire minimum. Provide 25 percent spare terminals in each panel.
- F. Time delay relays shall be combination on delay and off delay (selectable) with adjustable timing ranges. Provide socket with screw terminal connections and retaining strap. Time delay relays shall be **Square D, ATC, EATON**, or equal.

2.03 FACTORY TESTING

- A. Each panel/station shall be factory assembled and tested for sequence of operation prior to delivery.

2.04 SPARE PARTS

- A. Provide a minimum of 10 percent spare lamps (minimum 2) and one spare lens for each color pilot lamp in each panel.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Panels/stations shall be installed in accordance with in Section 16050 – General Electrical Work, and in accordance with the manufacturer's recommendations.
- B. Panels/stations shall be protected at the site from loss, damage, and the effects of weather. Panels/stations shall be stored in an indoor, dry location. Heating shall be provided in areas subject to corrosion and humidity.
- C. Panels/station interiors and exteriors shall be cleaned, and coatings shall be touched up to match original finish upon completion of the WORK.
- D. Conduit, conductors, and terminations shall be installed in accordance with Section 16050 – General Electrical Work.

3.02 FIELD TESTING

- A. Each panel/station shall be tested again for functional operation in the field after the connection of external conductors and prior to equipment startup.

END OF SECTION

SECTION 16671
SURGE PROTECTION DEVICES (SPD)

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. Provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install surge protective devices (SPD).
- B. SPDs furnished under this Section shall be ANSI/UL 1449 Type 2 integrating both surge suppression and high-frequency noise filtering suitable for use on low-voltage distribution systems.
- C. The requirements of Section 16050 – General Electrical Work, apply to the WORK of this Section

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. Reference Standards:
 - 1. ANSI/UL 1449, Fourth Edition, Safety Surge Protective Devices
 - 2. IEEE C62.41.1, Guide on the Surge Environment in Low-Voltage (1000V and Less) AC Power Circuits
 - 3. IEEE C62.45, Recommended Practice on Surge Testing for Equipment Connect to Low-Voltage (1000V and Less) AC Power Circuits
 - 4. UL 1283, Safety Electromagnetic Interference Filters
 - 5. NFPA 70, National Electric Code

1.03 SUBMITTALS

- A. Furnish submittals in accordance with Section 16050 – General Electrical Work.
- B. Shop Drawings:
 - 1. Electrical and mechanical drawings for each type of unit, showing electrical ratings, dimensions, mounting provisions, connection details, and layout diagrams.
- C. Product Data:
 - 1. Manufacturer's technical information, including catalog information.
 - 2. Manufacturer's technical specifications with assembly and component ratings.
- D. Certifications: Certification that SPD devices comply with standards referenced in this Section.

1.04 QUALITY ASSURANCE

- A. Qualifications:
 - 1. Manufacturer: Shall have at least five (5) years' experience manufacturing and servicing products substantially similar to those required and shall be able to submit documentation of at least 5 installations in satisfactory operation for at least five (5) years each.
- B. Component Supply and Compatibility:
 - 1. Obtain all products included in this Section regardless of component manufacturer from a single SPD manufacturer.
 - 2. SPD manufacturer shall review and approve or prepare all Shop Drawings and other submittals for all components furnished under this Section.
 - 3. Components shall be suitable for the specified service conditions and shall be integrated into overall assembly by SPD manufacturer.

PART 2 - PRODUCTS

2.01 GENERAL

- A. SPD shall be modular, high-energy, parallel design with fast-acting transient voltage suppression using metal oxide varistors. Equipment shall provide noise attenuation with electromagnetic interference filter.
- B. SPD shall be suitable for operation under the following environmental conditions:
1. Relative Humidity: Zero to 95%, non-condensing
 2. Frequency: 47 to 63 Hz
 3. Temperature: Zero to 149°F
 4. SPD operating voltage shall be suitable for the associated SPD location(s).
 5. SPD shall be suitable for internal and external mounting. SPD shall be factory-mounted and integrated into distribution equipment specified under the following Sections:
 - a. Section 16050 – General Electrical Work.
 - b. Section 16480 – Low Voltage Motor Control Centers
- C. SPD shall include a surge suppression path for each mode as required for the system configuration. Each mode shall be individually fused and equipped with thermal cutouts. SPD short-circuit current rating shall be 200 kA. Protection modes shall include, to the extent applicable, the following:
1. Line-to-line
 2. Line-to-neutral
 3. Line-to-ground
 4. Neutral-to-ground
- D. SPD shall include electromagnetic interference/radio frequency interference (EMI/RFI) noise rejection filter with attenuation up to 30 dB from 10 kHz to 100 MHz.
- E. SPDs and components in the operating path shall have maximum continuous operating voltage greater than 115% of nominal system operating voltage.
- F. ANSI/UL 1449 minimum withstand rating shall be 20 kA per pole, and ANSI/UL 1449 voltage protection rating for SPD shall not exceed the following:

Modes	208Y/120	480Y/277
L-N,L-G, N-G	800	1200
L-L	1200	2000

- G. SPD surge capacity based upon IEEE C62.41 location category shall, as a minimum, be the following:

Category	Application	Per Phase	Per Mode
C	Service entrance	240 kA	120 kA
B	High exposure locations (distribution equipment)	160 kA	80 kA
A	Branch locations	120 kA	60 kA

- H. Provide SPD equipped with the following accessories:
- I. Surge counter with display for indicating the number of surges detected.
- J. LED indicators for monitoring device status.
- K. Audible alarm and silence switch for indicating an inoperative condition.

- L. Dry contacts, "form C", for remote annunciation of unit status.
- M. Source Quality Control: Perform manufacturer's standard factory tests on equipment. Tests shall be in accordance with ANSI/UL 1449.
- N. Manufacturers: **General Electric, Eaton, Schneider Electric/Square D Company, or equal.**

PART 3 - EXECUTION

3.01 GENERAL

- A. Install SPD in accordance with equipment manufacturer's written recommendations and instructions and the Contract Documents.
- B. Where an SPD cannot be installed integral with the equipment to which it is connected, conductor length between suppressor and connection point shall be as short and as straight as possible.

END OF SECTION

PART 1 - GENERAL

3. IEEE 400 – 2001, Guide for Field Testing and Evaluation of the Insulation of Shielded Power Cable Systems
 4. IEEE 576 – 2000, Recommended Practice for Installation, Termination, and Testing of Insulated Power Cable as Used in Industrial and Commercial Applications
 5. NETA InterNational Electrical Testing Association
 6. NETA ATS, Acceptance Testing Specifications for Electrical Power Equipment and Systems.
 7. NETA MTS, Maintenance Testing Specifications for Electrical Power Equipment and Systems.
- C. The publications listed above form a part of this specification to the extent referenced.
- D. Where a date is given for reference standards, the edition of that date shall be used. Where no date is given for reference standards, the latest edition available on the date of the Notice Inviting Bids shall be used.

1.04 SUBMITTALS

- A. Submit in accordance with Section 01300 – Contractor Submittals.
- B. Submit complete system test procedures for review. Test procedures shall include but not be limited to:
1. Detailed procedures in sufficient detail to verify conformance with these Specifications.
 2. Incorporation of the Test Record Sheets included at the end of this Section.
 3. Detailed comprehensive testing schedule including:
 - a. Each major piece of electrical distribution equipment.
 - b. Each major electrical subsystem.
 - c. Duration of each test.
 - d. Milestone test completion date.
 - e. Ambient Conditions at time of test
 - f. Date of test results submittals following completion of the tests.
 - g. Names and qualifications of the individual(s) responsible for performing the testing.
- C. Following completion of the test submit the completed test results to the Engineer for review. The results shall include a dedicated section with the “as-left” settings of all devices, relays, circuit breakers, etc.
- D. Test result shall be submitted in one submittal
- E. Test reports shall be based on NETA’s latest Acceptance Testing Specifications having a sign-off, pass/fail data filed for each line item covered by NETA’s Acceptance Testing Specifications latest edition.

1.05 COMMISSIONING

- A. Commissioning during the 7 Day test shall not be attempted until all subsystems have been found to operate satisfactorily.
- B. Commissioning shall only be attempted as a function of normal plant operation in which plant process flows and levels are routine and equipment operates automatically in response to flow and level parameters or computer command, as applicable. Simulation of process parameters shall be considered only upon receipt of a written request by the CONTRACTOR.

1.06 TESTING ORGANIZATION QUALIFICATIONS

- A. Testing organization shall be corporately and financially independent of the supplier, producer and installer of the equipment.
- B. Testing organization shall meet Federal OSHA criteria for accreditation of testing laboratories, Title 29, Part 1907, 1910 and 1936. Membership in the National Electrical Testing Association constitutes proof of meeting such criteria.
- C. Testing organization shall provide all materials, equipment, labor and technical supervision to perform inspections and tests.

1.07 SAFETY AND PRECAUTIONS

- A. Safety practices shall include, but are not limited to, the following requirements:
 - 1. Occupational Safety and Health Act.
 - 2. Accident Prevention Manual for Industrial Operations, National Safety Council.
 - 3. Applicable state and local safety operating procedures.
 - 4. Owner's safety practices.
 - 5. National Fire Protection Association - NFPA 70E
 - 6. American National Standards for Personnel Protection
- B. All tests shall be performed with apparatus de-energized. Exceptions must be thoroughly reviewed to identify safety hazards and devise adequate safeguards.
- C. The testing firm shall have a designated safety representative on the project to supervise the testing operations with respect to safety.

PART 2 - TESTING & REPORTS

2.01 PRE-ENERGIZATION AND OPERATING TESTS

- A. The complete electrical system shall be performance tested when first installed on-site. Each protective, switching, and control circuit shall be adjusted in accordance with the recommendations of the protective device study and tested by actual operation using current injection or equivalent methods as necessary to ensure that each and every such circuit operates correctly to the satisfaction of the authority having jurisdiction.
 - 1. Instrument Transformers. All instrument transformers shall be tested to verify correct polarity and burden.
 - 2. Protective Relays. Each protective relay shall be demonstrated to operate by injecting current or voltage, or both, at the associated instrument transformer output terminal and observing that the associated switching and signaling functions occur correctly and in proper time and sequence to accomplish the protective function intended.
 - 3. Switching Circuits. Each switching circuit shall be observed to operate the associated equipment being switched.
 - 4. Control and Signal Circuits. Each control or signal circuit shall be observed to perform its proper control function or produce a correct signal output.
 - 5. Metering Circuits. All metering circuits shall be verified to operate correctly from voltage and current sources, similarly to protective relay circuits.
 - 6. Acceptance Tests. Complete acceptance tests shall be performed, after the station installation is completed, on all assemblies, equipment, conductors, and control and protective systems, as applicable, to verify the integrity of all the systems.

7. Relays and Metering Utilizing Phase Differences. All relays and metering that use phase differences for operation shall be verified by measuring phase angles at the relay under actual load conditions after operation commences.
- B. Test Report. A test report covering the results of the tests required in the Pre-Energization and Operating Tests shall be delivered to the authority having jurisdiction prior to energization. Acceptance Testing shall be in accordance with NETA ATS, Electrical Power Equipment and Systems.

PART 3 - EXECUTION

- A. The following test requirements supplement test and acceptance criteria that may be stated elsewhere.
- B. Perform Electrical Tests after electrical installation is 90% completed.

3.02 LIGHTING AND RECEPTACLES

- A. Switching, include remote control, if present in system. Circuitry is in accordance with panel schedules. All interior and exterior lighting shall be checked for proper operation.
- B. Test ground interrupter (GFI) receptacles and circuit breakers for proper operation by methods sanctioned by the receptacle manufacturer.

3.03 LOW-VOLTAGE CABLES-600V MAXIMUM

- A. Visual and Mechanical Inspection
 1. Compare cable data with drawings and specifications.
 2. Inspect exposed sections of cables for physical damage and proper connection in accordance with single-line diagram.
 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 in accordance with manufacturer's published data or NETA ATS, Table 100.12.
 4. Inspect compression-applied connectors for correct cable match and indentation.
 5. Inspect for correct identification, arrangements, and cable color coding.
 6. Inspect cable jacket insulation and condition.
- B. Electrical Tests
 1. Perform insulation-resistance test on each conductor with respect to ground and adjacent conductors. Applied potential shall be 500 volts dc for 300 volt rated cable and 1000 volts dc for 600 volt rated cable. Test duration shall be one minute.
 - a. Motor feeders shall be tested with motors disconnected and controller open.
 - b. Motor control circuits shall be tested and verified for proper operation with control stations and overcurrent devices connected.
 - c. Panelboard feeders shall be tested with feeder breaker open and panel-board connected. If a lighting transformer is associated with the panelboard, it shall be connected and the test made for both primary and secondary sides.
 - d. Conductors of main lighting feeders, including lighting panel shall be tested with branch circuits open.
 2. Prior to performing insulation resistance tests on cables, verify that they are not connected to a solid-state device.

- a. Equipment shall be disconnected to avoid damage during prior to testing.
 - b. The CONTRACTOR shall notify Engineer if minimum insulation values cannot be obtained.
3. Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.
4. Perform continuity test to insure correct cable connection.
- C. Test Values – Visual and Mechanical
 1. Compare bolted connection resistance to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 2. Bolt-torque levels should be in accordance with NETA ATS, Table 100.12 unless otherwise specified by the manufacturer.
- D. Test Values – Electrical
 1. Compare bolted connection resistance values to values of similar connections. 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. In the absence of manufacturer's published data, use NETA ATS Table 100.1. Values of insulation resistance less than this table or manufacturer's recommendations shall be investigated to determine cause of deviations.
 3. Cable shall exhibit continuity.
 4. Deviations in resistance between parallel conductors shall be investigated to determine cause of deviations.

3.04 CIRCUIT BREAKERS - LOW-VOLTAGE - INSULATED-CASE

- A. Visual and Mechanical Inspection
 1. Check circuit breaker for proper mounting and compare nameplate data to drawings and specifications.
 2. Operate circuit breaker to ensure smooth operation.
 3. Inspect case for cracks or other defects.
 4. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS- 2017, Table 100.12.
- B. Electrical Tests
 1. Perform a contact-resistance test.
 2. Perform insulation-resistance test on each conductor with respect to ground and adjacent conductors. Applied potential shall be 500 volts dc for 300 volt rated cable and 1000 volts dc for 600 volt rated cable. Test duration shall be one minute.
 3. Determine long-time minimum pickup current by primary current injection where practical.
 4. Perform long-time delay time-current characteristic test by passing three hundred percent (300%) rated current through each pole separately. Record trip time.
 5. Determine short time pickup and delay by primary current injection.
 6. Determine ground-fault pickup and time delay by primary current injections.
 7. Determine instantaneous pickup current by primary injection using run-up or pulse method.

C. Test Values

1. Compare contact resistance or millivolt drop values to adjacent poles and similar breakers. Investigate deviations of more than fifty percent (50%). Values of resistance less than this table or manufacturer's recommendations shall be investigated to determine cause of deviations.
2. Insulation resistance shall not be less than 100 megohms.
3. Trip characteristic of breakers shall fall within manufacturer's published time-current characteristic tolerance band, including adjustment factors.
4. All trip times shall fall within Table ICO. Circuit breakers exceeding specified trip time at three hundred percent (300%) of pickup shall be tagged defective.
5. Instantaneous pickup values shall be within values shown on Table ICI.

Table ICO Insulated-Case Circuit Breaker Overcurrent Trip Test (At 300% of Rated Continuous Current of Circuit Breaker)		
Maximum Breaker Voltage Volts	Range of Related Continuous Current Amperes	Maximum Trip Time in Seconds*
240	15-45	50
240	50-100	70
600	15-45	70
600	50-100	125
240	110-225	200
240	250-400	300
600	110-225	250
600	250-400	300
600	450-600	350
600	700-1200	500
600	1400-2500	600
600	3000-5000	650

*For integrally-fused circuit breakers, trip times may be substantially longer if tested with the fuses replaced by solid links (shorting bars).

Table ICI Insulated-Case Circuit Breaker Instantaneous Trip Tolerances		
Frame Size, Amperes	Tolerances of High and Low Settings	
	High	Low
<250	+40% -25%	+40% -30%
>400	+25%	+30%

3.05 CIRCUIT BREAKERS - LOW-VOLTAGE - POWER

A. Visual and Mechanical Inspection

1. Inspect for physical damage and compare nameplate data with drawings and specifications.
2. Perform mechanical operation test in accordance with manufacturer's instructions.
3. Check cell fit and element alignment and proper operation of racking interlocks.
4. Bolt-torque levels should be in accordance with NETA ATS, Table 100.12 unless otherwise specified by the manufacturer.
5. Check arc chutes for damage.
6. Clean entire circuit breaker using approved methods and materials.
7. Lubricate as required.

B. Electrical Tests

1. Perform a contact-resistance test.
2. Perform an insulation-resistance test at 1000 volts dc from pole-to-pole and from each pole-to-ground with breaker closed and across open contacts of each phase.
3. Determine long-time minimum pickup current by primary current injection.
4. Determine long-time delay by primary 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. Make adjustments for final settings in accordance with breaker setting sheet.
9. Activate auxiliary protective devices, such as ground-fault or under voltage relays, to ensure operation of shunt trip devices. Check the operation of electrically-operated breakers in their cubicle.
10. Check charging mechanism.

C. Test Values

1. Compare contact resistance or millivolt drop values to adjacent poles and similar breakers. Investigate deviations of more than fifty percent (50%).
2. Insulation resistance shall not be less than 100 megohms. Investigate values less than 100 megohms.
3. Trip characteristics of breakers when adjusted to setting sheet parameters shall fall within manufacturer's published time-current tolerance band.

3.06 INSTRUMENT TRANSFORMERS

A. Visual and Mechanical Inspection

1. Inspect for physical damage and nameplate information for compliance with drawings and specifications.
2. Verify proper connection of transformers with system requirements.
3. Verify tightness of all bolted connections and assure that adequate clearances exist between primary circuits and secondary circuit wiring.
4. Verify that all required grounding and shorting connections provide good contact.
5. Test proper operation of transformer withdrawal mechanism (tip out) and grounding operation when applicable.

6. Verify proper primary and secondary fuse sizes for potential transformers.

B. Electrical Tests - Current Transformers

1. Perform insulation-resistance test of the current transformer and wiring-to-ground at 1000V dc. Do not perform this test on solid-state devices.
2. Perform a polarity test of each current transformer.
3. Perform a ratio-verification test using the voltage or current method in accordance with ANSI C57.13.1.
4. Perform an excitation test on transformers used for relaying applications in accordance with ANSI C57.13.1.
5. Measure relaying circuit burdens at transformer terminals and determine the total burden in ohms at 60Hz.
6. When applicable, perform insulation-resistance and dielectric withstand tests on the primary winding with secondary grounded. Test voltages shall be per NETA ATS, Table 100.1 and ITD respectively.

C. Electrical Tests - Voltage Transformers

1. Perform insulation-resistance tests winding-to-winding and windings-to-ground. Test voltages shall be applied for one (1) minute in accordance with NETA ATS, Table 100.1. Do not perform this test with solid-state devices connected.
2. Perform a polarity test on each transformer to verify the polarity marks or H1-X1 relationship as applicable.
3. Perform a ratio test using a transformer-turns-ratio test set or by voltage comparison method.
4. Perform a dielectric withstand test on the primary windings with the secondary windings connected-to-ground. The dielectric voltage shall be in accordance with Table ITD and applied for one (1) minute.

D. Test Values

1. Insulation-resistance measurement on any instrument transformer shall be not less than that shown in NETA ATS, Table 100.1.
2. Perform a burden/saturation calculation on current transformers supplying relaying circuits.
3. Ratio accuracies shall be within 0.5% of nameplate or manufacturer's specifications.
4. Withstand tests shall be evaluated as pass/fail.

Table ITD Instrument Transformer Dielectric Test Voltage			
Nominal System Voltage	Test BIL (kV)	Dielectric Withstandability Field Test Voltage (kV)	
		AC	DC
2.4	45	11.3	15
4.8	60	14.3	19
13.8	95	25.5	34
13.8	110	25.5	34
25	125	30.0	40

25	150	37.5	50
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Table is derived from paragraph 8.8.2 and tables 2 and 7 of ANSI/IEEE C57.13, "Standard Requirements for Instrument Transformers."

3.07 METERING AND INSTRUMENTATION

A. Visual and Mechanical Inspection

1. Examine all devices for broken parts, shipping damage, and tightness of connections.
2. Verify that meter types, scales, and connections are in accordance with drawings and specifications.

B. Electrical Tests

1. Determine accuracy of meters at 25/50/75/100% of full scale for each metered parameter.
2. Calibrate meters to one-half percent (0.5%).
3. Verify all instrument multipliers.

3.08 GROUNDING SYSTEMS

A. Visual and Mechanical Inspection:

1. Inspect ground system for compliance with contract documents and NFPA 70 National Electrical Code Article 250.
2. Inspect physical and mechanical conditions.
3. Inspect bolted electrical connection for high resistance using one or more of the following methods:
 - a. Use of low-resistance ohmmeter
 - b. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench methods in accordance with manufacturer published data and NETA ATS Table 100.12.
4. Inspect anchorage.

B. Electrical Tests

1. Perform ground-impedance measurements utilizing the fall-of-potential method per ANSI/IEEE Standard 81 "IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System." Instrumentation utilized shall be as defined in Section 12 of the above guide and shall be specifically designed for ground impedance testing. Provide sufficient spacing so that plotted curves flatten in the 62% area of the distance between the item under test and the current electrode.
2. Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, system neutral, and derived neutral points.

C. Test Values

1. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2. The resistance between the main grounding electrode and ground shall be no greater than five ohms for large commercial or industrial systems and one ohm or less for generating or transmission station grounds unless otherwise specified by the owner. (Reference ANSI/IEEE Standard 142).
3. Investigate point-to-point resistance values that exceed 0.5 ohm.

3.09 GROUND-FAULT SYSTEMS (NEC 230-95)

A. Visual and Mechanical Inspection

1. Inspect for physical damage and compliance with drawings and specifications.
2. Inspect neutral main bonding connection to assure:
 - a. Zero-sequence sensing system is grounded.
 - b. Ground-strap sensing systems are grounded through sensing device.
 - c. Ground connection is made ahead of neutral disconnect link on zero-sequence sensing systems.
 - d. Grounded conductor (neutral) is solidly grounded.
3. Inspect control power transformer to ensure adequate capacity for system.
4. Manually operate monitor panels (if present) for:
 - a. Trip test
 - b. No trip test
 - c. Nonautomatic reset
5. Record proper operation and test sequence.
6. Set pickup and time-delay settings in accordance with the settings provided by the owner/user's electrical engineer.

B. Electrical Tests

1. Measure system neutral insulation resistance to ensure no shunt ground paths exist. Remove neutral-ground disconnect link. Measure neutral insulation resistance and replace link.
2. Determine the relay pickup current by current injection at the sensor and operate the circuit interrupting device.
3. Test the relay timing by injecting three hundred percent (300%) of pickup current, or as specified by manufacturer.
4. Test the system operation at fifty-seven percent (57%) rated control voltage, if applicable.
5. Test zone interlock systems by simultaneous sensor current injection and monitoring zone blocking function.
6. On multiple sources, tie breaker, etc., systems, devise a simulation scheme that fully proves correct operation.

C. Test Parameters

1. System neutral insulation shall be a minimum of one hundred (100) ohms, preferably one (1) megohm or greater.
2. Relay timing shall be in accordance with manufacturer's published time-current characteristic curves but in no case longer than one (1) second for fault currents equal to or greater than 3,000 amperes.
3. Relay pickup value shall be within +/-10% of setting and in no case greater than 1200A.

3.10 AC MOTORS

A. Visual and Mechanical Inspection

1. Inspect for physical damage and compare nameplate data with drawings and specifications.
2. Inspect for proper anchorage, mounting, grounding, connection, and lubrication.

3. When applicable, perform special tests such as air gap spacing and pedestal alignment.
4. Check for unusual mechanical or electrical noise or signs of overheating during initial test run.

B. Electrical Tests - Induction Motors

1. Perform insulation-resistance tests in accordance with ANSI/IEEE Standard 43.
2. Motor 200 HP and Less - Test duration shall be one minute with resistances tabulated at thirty and sixty seconds. Calculate the dielectric absorption ratio.
3. Motor Larger than 200 HP - Test duration shall be ten minutes with resistances tabulated at thirty seconds, one minute, and ten minutes. Calculate the dielectric absorption ratio and polarization indexes.
4. Perform insulation-resistance test on pedestal per manufacturer instructions.
5. Test motor starter prior to energizing the motor.
6. Check resistance temperature detector (RTD) circuits for conformance with drawings. Check that metering or relaying devices using the RTD's are of the proper rating.
7. Check that the motor space heater circuit is in proper operating condition and in accordance with drawings and specifications.
8. Check all protective devices in accordance with other sections of these specifications.
9. Perform a rotation test to ensure proper shaft direction.
10. Measure running current and evaluate relative to load conditions and nameplate full-load amperes.
11. Perform vibration tests: Motors Larger than 200 HP - Perform vibration base-line test. Amplitude shall be plotted versus frequency. For motors 200 HP and less perform vibration and amplitude test.

C. Test Values

1. Perform insulation-resistance tests at the test voltage listed in NETA ATS, Table 100.1. Investigate dielectric absorption ratios less than 1.4 and polarization index ratios less than 1.5 for Class A insulation and 2.0 for Class B insulation.
2. Vibration amplitudes shall not exceed values shown in Table MAV.
3. Salient pole voltage drop should be equal for each pole. Investigate values that differ by more than ten percent (10%).

Table MAV Maximum Allowable Vibration Per NEMA MG-1	
Speed RPM	Amplitude Inches Peak-to-Peak
3000 and above	0.001
1500-2999	0.0015
1000-1499	0.002
999 and below	0.0025

3.11 LOW-VOLTAGE MOTOR CONTROL CENTERS

A. Visual and Mechanical Inspection

1. Inspect for physical damage, proper anchorage, and grounding.
2. Inspect equipment for compliance with drawings and specifications.

3. Motor-running protection:

- a. Compare overload heater rating with motor full-load current rating to verify proper sizing. (Adjust as necessary if power factor correction capacitors are connected on load side of heaters.)

4. Check tightness of bolted connections using calibrated torque wrench.

B. Electrical Tests

1. Insulation tests:

- a. Measure insulation resistance of each bus section phase-to-phase and phase-to-ground for one (1) minute. Test voltage shall be in accordance with NETA ATS, Table 100.1.
- b. Measure insulation resistance of each starter section phase-to-phase and phase-to-ground with the starter contacts closed and the protective device open. Test voltage shall be in accordance with NETA ATS, Table 100.1.
- c. Measure insulation resistance of each control circuit with respect to ground. Refer to NETA ATS, Table 100.1. Do not perform this test on wiring connected to solid-state components.

2. Test motor overload units by injecting current through overload unit and monitoring trip time at three hundred percent (300%) of motor full-load current.

3. Test molded-case breakers per Low Voltage Insulated Case Circuit Breakers paragraphs.

4. Perform operational tests by initiating control devices to affect proper operation.

5. Determine accuracy of all meters per Metering and Instrumentation paragraphs.

6. Test protective devices in accordance with Protective Relay paragraphs.

C. Test Values

1. Bolt-torque levels should be in accordance with NETA ATS, Table 100.12 unless otherwise specified by the manufacturer.

2. Insulation-resistance test results shall conform with NETA ATS, Table 100.1.

3. Control wiring-insulation test voltage shall be 500V dc for 300-volt rated cables and 1000V dc for 600-volt rated cables. Do not perform this test on wiring connected to solid-state components.

4. Perform overload tests at three hundred percent (300%) of motor full-load current. Trip times shall be in accordance with manufacturer's tolerances. Investigate values in excess of one hundred twenty (120) seconds.

3.12 TEST REPORTS

A. The test report shall include the following:

1. Summary of project.
2. Description of equipment tested.
3. Description of test.
4. Test data.
5. Analysis and recommendations.

B. Test data records shall include the following minimum requirements:

1. Identification of the testing organization.
2. Equipment identification.

3. Humidity, temperature, and other atmospheric conditions that may affect the results of the tests/calibrations.
 4. Date of inspections, tests, maintenance, and/or calibrations.
 5. Identification of the testing technician.
 6. Indication of inspections, tests, maintenance, and/or calibrations to be performed and recorded.
 7. Indication of expected results when calibrations are to be performed.
 8. Indication of "as-found" and "as-left" results.
 9. Sufficient spaces to allow all results and comments to be indicated.
- C. The testing firm shall furnish a copy or copies of the complete report to the owner as required in the acceptance contract.

END OF SECTION

SECTION 17010
INSTRUMENTATION AND CONTROLS FOR PROCESS SYSTEMS

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. The CONTRACTOR shall provide Instrumentation and Control System (I&CS) complete and operable, in accordance with the Contract Documents.
- B. The Division 17 drawings and specifications are to be read together with drawings and specifications of all other Divisions and specifically Division 16. Additional information necessary to complete the work is included in other sections of the drawings and specifications.
- C. The requirements of this Section apply to every component of the I&CS unless indicated otherwise.
- D. All tables shown of the Division 17 drawings and specifications are for information purposes only and may show partial lists of equipment and materials. A complete take-off from all drawings and specifications shall be done by the CONTRACTOR in order to determine accurate quantities of equipment and materials
- E. The PLC and SCADA system programming modifications shall be performed by OTHERS.

1.02 DEFINITIONS AND ACRONYMS

- A. System Supplier: The System Supplier shall be a single firm, corporation, or other entity assuming full responsibility through the CONTRACTOR to perform all engineering and to select, furnish, program, configure, integrate, supervise the installation and connections, test, calibrate, and place into operation all instrumentation, controls, communication hardware and software. The System Supplier shall specialize and have an experienced engineering and technical staff in the design, integration, and supply of systems similar to the one in these Contract Documents.
- B. AI/AO Analog Input/Output
- C. CMMS Computerized Maintenance Management System
- D. DI/DO Digital Input/Output
- E. FOC Fiber Optic Cable
- F. HMI Human Machine Interface
- G. HSE High Speed Ethernet
- H. I/O Input/Output Signals
- I. LAN Local Area Network
- J. LIMS Laboratory Information Management System
- K. MM Multimode (Fiber)
- L. OIT Operator Interface Terminal
- M. OPC OLE for Process Control (communication interface driver)
- N. PID Proportional, Integral and Derivative Process Controller
- O. PLC Programmable Logic Controller
- P. PS Pump Station
- Q. RAM Random Access Memory
- R. SCADA Supervisory Control and Data Acquisition
- S. SM Single Mode (Fiber Optic)

- T. UPS Uninterruptible Power Supply
- U. WAN Wide Area Network
- V. WTP Water Treatment Plant
- W. WWTP Wastewater Treatment Plant

1.03 RESPONSIBILITIES

- A. The CONTRACTOR, through the use of a single System Supplier and qualified electrical and mechanical installers, shall be responsible for the implementation of the I&CS and the integration of the I&CS with other required instrumentation and control devices.
- B. Due to the complexities associated with the interfacing of numerous control system devices, it is the intent of these specifications that the System Supplier will be responsible to the CONTRACTOR for the integration of the I&CS with existing devices and devices provided under this and other Divisions with the objective of providing a completely integrated control system free of signal incompatibilities.
- C. As a minimum, the implementation of the I&CS by the CONTRACTOR shall include the following WORK:
 - 1. Integrate the I&CS with existing devices and systems provided under this and other Divisions
 - 2. Prepare the required I&CS submittals
 - 3. Design and develop project-wide loop diagrams including those associated with equipment provided under other Divisions and OWNER-furnished and existing equipment
 - 4. Design and develop control panel drawings
 - 5. Field verify existing conditions
 - 6. Prepare factory and field test submittals
 - 7. Prepare training plan
 - 8. Prepare spare parts submittal
 - 9. Procure hardware and software
 - 10. Configure and factory test the I&CS
 - 11. Bench calibrate instruments and verify calibration after installation
 - 12. Terminate signals inside control and network panels; terminate communication and network devices and nodes
 - 13. Supervise and coordinate installation and termination of field signals, power, and utilities associated with the I&CS. Resolve signal, power, or functional incompatibilities between the I&CS and new and existing interfacing devices.
 - 14. Loop test in accordance with the loop diagrams. Validate and certify loops
 - 15. Oversee, document, and certify system commissioning
 - 16. Conduct system performance test
 - 17. Prepare technical manuals
 - 18. Conduct training classes
 - 19. Prepare I&CS as-built final construction drawings
- D. Any Instrumentation Supplier responsibilities in addition to the list above are at the discretion of the CONTRACTOR and the Instrumentation Supplier. Additional requirements in this Section and throughout Division 17 that are stated to be the CONTRACTOR's responsibility may be performed by the Instrumentation Supplier if the CONTRACTOR and Instrumentation Supplier so agree.

1.04 RELATED WORK

- A. Section 17010 Instrumentation and Control for Process Systems
- B. Division 16 Electrical Specifications
- C. All electrical work required under this section shall conform to the requirements of Division 17 and the applicable requirements of Division 01, Division 16.

1.05 REGULATORY AGENCIES AND STANDARDS

- A. Without limiting the generality of other requirements of these Specifications, all WORK specified herein shall conform to or exceed the applicable requirements of the referenced documents to the extent that the requirements therein are not in conflict with the provisions of this Section; provided, that where such documents have been adopted as a code or ordinance by the public agency having jurisdiction, such code or ordinance shall take precedence.
- B. The I&CS WORK shall conform to or exceed the applicable regulations, standards, specifications, and codes which are referenced in Section 014219 Reference Standards, and current as of the date of the final inspection for this Contract, including, but not limited to, those which are established by the following sources:
1. The International Society of Automation (ISA)
 2. National Electrical Code (NEC)
 3. National Fire Protection Association (NFPA)
 4. Institute of Electrical and Electronic Engineers (IEEE)
 5. Occupational Safety and Health Administration (OSHA)
 6. American National Standards Institute (ANSI)
 7. National Electrical Manufacturers Association (NEA)
 8. Insulated Cable Engineers Association (ICEA)
 9. Local Power and Telephone Companies
 10. Local Authorities having jurisdiction over the work
 11. Federal Communication Commission (FCC)
 12. Underwriter Laboratory (UL)
- C. Where the requirements set forth in these Specifications or on the Drawings are greater or more rigid than the mandatory requirements referenced above, the applicable Specifications or Drawings shall govern.
- D. In the case of conflict between any mandatory requirements and Specifications or Drawings, the mandatory requirement shall be followed in each case, but only after submitting such proposed changes to the ENGINEER for approval.
- E. Nothing contained in these Specifications or shown on the Drawings will be so construed to conflict with any national, state, municipal, or local laws or regulations governing the installation of work specified herein, and all such acts, ordinances, and regulations, including the National Electrical Code, are hereby incorporated and made a part of these Specifications. All such requirements will be satisfied by the CONTRACTOR at no additional expense to the OWNER.
- F. The Drawings and Specifications are complementary to each other; what is called for by one shall be as binding as if called for by both. If a conflict between Drawings and Specifications is discovered, this shall be referred to the ENGINEER as soon as possible for resolution. Should a conflict exist between the Drawings, Specifications, and/or mandatory requirements (i.e., codes, ordinances, etc.), it will be assumed that the more expensive method has been estimated, unless such alternate has been agreed to prior to submission of bids.

1.06 SUBMITTALS

- A. Furnish submittals in accordance with the requirements of Section 01330 – Submittal Procedures and 17010 - Instrumentation and Control for Process Systems.
- B. The CONTRACTOR shall coordinate the I&CS part of the WORK so that a complete instrumentation and control system will be provided and will be supported by accurate Shop Drawings and as-built drawings.
- C. The submittals and their schedules shall be in accordance with the requirements listed below: Any incomplete submittal will be rejected and returned without comments.
- D. Interface between instruments, motor control centers, engines, starters, control valves, flowmeters and other equipment related to the I&CS shall be included in the shop drawing submittal. Interface between existing equipment, instruments and control panels shall also be included.
- E. The CONTRACTOR shall be submitted in paper and electronic (PDF) format and shall include but not be limited to:
 - 1. Equipment descriptive data, including equipment tag as identified in the contract documents.
 - 2. Full manufacturer's part number indicating all selected options.
 - 3. Equipment installation, service manuals, operation/maintenance manuals and recommended spare parts lists.
 - 4. Schematics and interconnecting wiring diagrams.
 - 5. Records of conductor identification, field terminals, changes, etc.
 - 6. Instrumentation and control panel shop drawings, face layouts, schematics and point-to-point wiring diagrams.
 - 7. Ethernet network control system architecture drawings complete with wiring identification numbers.
 - 8. Records of as-built information for the control system components.
- F. Symbols and Nomenclature: In these Contract Documents, systems, meters, instruments, and other elements are represented schematically, and are designated by symbols as derived from Instrument Society of America Standard ISA S5.1 - Instrumentation Symbols and Identification. The nomenclature and numbers designated herein and on the Drawings shall be employed exclusively throughout Shop Drawings, and similar materials. No other symbols, designations, or nomenclature unique to the manufacturer's standard methods shall replace those prescribed above, used herein, or on the Drawings.
- G. Shop Drawings shall include the letter head or title block of the System Supplier. The title block shall include, as a minimum, the System Supplier's registered business name and address, project name, drawing name, revision level, and personnel responsible for the content of the drawing.
 - 1. Organization of the Shop Drawing submittals shall be compatible with eventual submittals for later inclusion in the Technical Manual. Submittals not so organized will not be accepted.
 - 2. For a project with multiple sites the CONTRACTOR shall provide a separate and unique set of drawings for each site.
 - 3. Drawings that require more than one sheet due to space limitation or continuation in the subject of the drawings (e.g. loop diagrams, etc.) shall be given the same drawing number but with different sheet number (e.g. sheet 1 of x, sheet 2 of x, etc.).
 - 4. Each submittal shall include a complete index appearing in the front of each bound submittal volume. Drawings and/or system groups shall be separated by labeled tags. The

organization of the initial shop drawing submittal required above shall be compatible to eventual inclusion with the Technical Manuals submittal and shall include final alterations reflecting as-built conditions.

5. Interfaces between new and existing instruments, motor starters, control valves, variable speed drives, flow meters, chemical feeders, panels, and other equipment related to the I&CS shall be included in the Shop Drawing submittal.

H. Field Instrument Submittal

1. Submittal Schedule: The CONTRACTOR shall submit for approval a complete field and process instrument submittal, **all at one time, within 60 calendar days** after the date of Notice to Proceed is given to the CONTRACTOR.
2. Submittal Contents: The submittal shall include a complete index which lists each device by tag number, type, and manufacturer in accordance with the specified data sheets provided in this CONTRACT. A separate manufacturer technical brochure or catalog sheet shall be included with each specified instrument data sheet. If, within a single system or loop, a single instrument is employed more than once, one manufacturer brochure or catalog sheet may cover multiple identical uses of that instrument in that system. Each manufacturer brochure or catalog sheet shall include a list of tag numbers for which it applies. System groups shall be separated by labeled tags. Special options and features which are furnished shall be identified.

I. System Hardware Submittal:

1. Submittal Schedule: The CONTRACTOR shall submit for approval a complete system hardware submittal, **all at one time, within 90 calendar days** after the date of Notice to Proceed is given to the CONTRACTOR. This submittal shall be submitted together with the submittal for the System Architecture, and Communication Diagrams submittal and the Project-Wide Wiring Diagrams and Panel Drawings submittal specified below.

J. Project-Wide Wiring Diagrams and Panel Drawings Submittal

1. Submittal Schedule: The CONTRACTOR shall submit for approval a complete set of project-wide wiring diagrams (PWWD) and panel drawings, **all at one time within 120 calendar days** after the date of Notice to Proceed is given to the CONTRACTOR. The PWWD and panel drawings shall be a singular complete hard copy bound package and accompanied with a PDF on a CD. This submittal shall be submitted together with the System Hardware submittal and the System Architecture and Communication Diagrams submittal specified herein.
2. Submittal Contents: The PWWD and panel drawings shall be submitted as a single and comprehensive set of drawings. The submittal shall include a complete index in the front of each part of the submittal. The drawings shall be indexed by systems, sites, or process areas. Diagrams shall be tagged in a manner consistent with the Contract Documents.

K. Factory Test Procedure Submittal:

1. Submittal Schedule: The CONTRACTOR shall submit for approval a comprehensive factory acceptance test (FAT) procedure **complete within 180 calendar days** after the date of Notice to Proceed is given to the CONTRACTOR, but not later than 60 **calendar days** prior to the Factory Acceptance Test date.
2. Submittal Contents:
 - a. The CONTRACTOR shall develop and submit a factory test procedures to show that the integrated system hardware and software is fully operational and in compliance with the requirements of the Contract Documents.

- b. Procedure Format: The test procedure shall have a table of contents and each procedure shall be provided on a separate sheet or sheets.

1.07 CLOSEOUT SUBMITTALS

- A. In addition to the requirements specified in Division 01, provide the following information:
 - 1. Information in the Technical Manual shall be based upon the approved Shop Drawing submittals as modified for conditions encountered in the field during the WORK. The Technical Manuals shall therefore contain the as-built drawings and information.
 - 2. The Technical Manuals shall include installation, connection, operating, calibration, set points (e.g., pressure, pump control, time delays, etc.) adjustment, test, troubleshooting, maintenance, and overhaul instructions in complete detail.
 - 3. The Manuals shall have the following material organized in volumes and divided by subject and tabs The Technical Manual shall have the following organization for each process (the number and the enumeration of the sections shall be project specific):
 - a. Section A - Process and Instrumentation Diagrams (as built copy)
 - b. Section B - System Architecture and Communication System Block Diagram(s)
 - c. Section C - Wiring Diagrams. A separate set of drawings shall be provided for each site. Each set shall be arranged in a separate tab (drawings shall also be provided in PDF).
 - d. Section D – Functional design report. It shall include a copy of the site graphic display(s) and description how the site is controlled and any special control strategies specific for each site. Special control functions in the server shall also be included. Calibration, set points (e.g., pressure, pump control, time delays, etc.) shall also be included.
 - e. Section E - Instrument Data Sheets and corresponding manufacturer's data sheet/catalog cuts/brochure that was used in the hardware submittal and the operation and maintenance/user manual.
 - f. Section F - Calibration Documentation
 - g. Section G – Communication survey and test results
 - h. Section H - Loop, Commissioning and Performance Test Results

1.08 COORDINATION

- A. The drawings and specifications shall be read and interpreted in conjunction with other Divisions.
- B. The responsibility to determine which Division provides various products and work rests with the Contractor. Additional compensation will not be considered because of differences in interpretation of specifications.
- C. Provide work plan and identify methodologies for equipment installation with provision made for the most expeditious means to complete the work.
- D. Treat any item or subject omitted from this Division's specifications, but which is mentioned or reasonably specified in other Divisions' specifications or drawings and pertains to the instrumentation and control system, as being integral to the overall system. Provide such specified items or subjects.
- E. Structural members shall not be cut without prior approval of the ENGINEER.
- F. The Contractor is responsible to coordinate their work with other trades, and the OWNER'S Representative.
- G. The Contractor is responsible for determining cable lengths for manufacturer supplied equipment and devices with integrated cables.

1.09 QUALITY ASSURANCE

A. Factory Acceptance Tests (FAT)

1. Prior to shipment, the I&CS including all panels, integrated SCADA system, PLCs, peripherals, communications equipment, etc. provided under this Division, shall be assembled, connected, and all software loaded for a full functional factory acceptance test (FAT) of the integrated system. Existing equipment is not required to be included in this test.
 2. In preparation for the FAT, the CONTRACTOR shall check, troubleshoot, debug and test the I&CS prior to arrival of the ENGINEER in order for the I&CS to be ready for the FAT, minimize testing time, and minimize re-testing during the visit. Similar testing shall be performed even if the ENGINEER chooses not to witness the FAT.
 3. The CONTRACTOR shall allow the ENGINEER and OWNER to inspect the I&CS and witness the functional testing of the system at the site of assembly and integration of the system.
 4. A minimum of 21 Days notification shall be given to the ENGINEER prior to testing. No shipments shall be made without the ENGINEER's approval. A successful completion of the test is a prerequisite to the shipment of the system.
 5. The factory acceptance test shall be conducted at the place where the system was engineered, fabricated, assembled, and programmed.
 6. During the factory acceptance test, the CONTRACTOR's Project Manager and software engineers (HMI application software and PLC programming) who worked on the I&CS shall be available on the premises where the test is being conducted for explanation, demonstration or corrections.
 7. After the successful completion of the test, the ENGINEER will generate a punch list. The list may include items that must be corrected or addressed prior to the shipment of the system, and/or items that must be corrected later in the field during installation and startup.
- B. Field Tests: The CONTRACTOR's attention is directed to the Article "EXECUTION" of this Section which delineates all the tests that are required to be performed in the field in order to demonstrate compliance with the Contract Documents.
- C. The CONTRACTOR shall provide and assign to the OWNER all user software and hardware licenses. Computer and software system shall be purchased on behalf of the OWNER who shall also be designated as the licensee. Each software package shall be provided with a "Site License" or with as many licenses as a "Site License" includes (site is defined as the name of the OWNER). The CONTRACTOR shall include in the bid price all license fees.
- D. The CONTRACTOR shall provide the proper number of software licenses for all the servers, workstations, and laptops to provide concurrent and simultaneous user operation.
- E. Prior to final acceptance of the I&CS System and related equipment, the CONTRACTOR shall propose and present in writing to the OWNER a one-year maintenance contract and quotation which will become effective upon the expiration of the warranty. The maintenance contract is an option that the OWNER may purchase from the System Supplier. The contract shall offer different maintenance, site visit and help-desk with options each with its respective cost.

1.10 FIELD SITE CONDITIONS

- A. Site Equipment:
- B. Ambient temperature range: -18° through 60° C
- C. Thermal shock: 1.0° (1.8° F) per minute maximum
- D. Relative humidity: 95 percent maximum non-condensing.

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- E. Unless specified otherwise, provide equipment and instrumentation suitable for continuous operation at an elevation of 3300 feet above sea level.
- F. Classification of Plant Areas.
 - 1. Refer to Division 16.

1.11 WARRANTY

- A. All parts, material labor, travel, subsistence, or other expenses incurred in providing services and service visits during the warranty period shall be borne by the CONTRACTOR under the guarantee specified in Division 1. Equipment, software, and materials that do not achieve their intended purpose shall be replaced by the CONTRACTOR to attain compliance, at no additional cost to the OWNER.
- B. The performance of the servers and workstations hardware shall be guaranteed (repair of parts and labor at the owner's site including travel expenses) for a period of three (3) years following the date of completion and formal acceptance of the work (next business day on-site service).
- C. Software Upgrades: During the warranty period, the CONTRACTOR shall furnish and install at no additional cost to the OWNER any application software upgrades published applicable to OWNER's applications and compatible with OWNER's hardware and operating system.

PART 2 - PRODUCTS

2.01 GENERAL

- A. Standard and Current Technology: All I&CS hardware, software, materials, and equipment furnished under this contract shall be new, free from defects, and shall be standard products and technology produced by manufacturers regularly engaged in the manufacture of these products. Meters, instruments, and other components shall be the most recent field-proven models marketed by their manufacturers at the time of submittal of the Shop Drawings unless otherwise required to match existing equipment.
- B. The CONTRACTOR shall submit a Substitute Item Request Form in case of discontinued or upgraded product or other cases where changing technology requires changes in equipment or software.
- C. Adverse Environmental Impact: No component of an instrumentation system shall contain liquid mercury.
- D. Hardware Commonality and Modularity: Instruments which utilize a common measurement principle shall be furnished by a single manufacturer. Panel mounted instruments shall have matching style and general appearance. Instruments performing similar functions shall be of the same type, model, or class, and shall be from a single manufacturer. All equipment shall be of modular design to facilitate interchangeability of parts to assure ease of servicing and expandability.
- E. Instrument and Loop Power: Power requirements and input/output connections for components shall be verified. Power for transmitted signals shall, in general, originate in and be supplied by the control panel devices. The use of "2 wire" transmitters is preferred, and use of "4 wire" transmitters shall be minimized. Individual loop or redundant power supplies shall be provided as specified and/or as required by the manufacturer's instrument load characteristics to ensure sufficient power to each loop component. Power supplies shall be mounted within control panels or in the field at the point of application.
- F. Loop Isolators and Converters: The CONTRACTOR is responsible to resolve any signal level incompatibilities where required.
- G. Signal Levels: Analog measurements and control signals shall be as indicated herein, and unless otherwise indicated, shall vary in direct linear proportion to the measured variable. Electrical

signals outside control panels shall be 4 to 20 milliamperes DC except as indicated. Signals within enclosures may be 1 to 5 volts DC. Electric signals shall be electrically or optically isolated from other signals. Pneumatic signals shall be 3 to 15 psig with 3 psig equal to 0 percent and 15 psig equal to 100 percent.

- H. Alternative Equipment and Methods: Equipment or methods requiring redesign of any project details are not acceptable without prior written approval of the ENGINEER through the "or equal" process. Any proposal for approval of alternative equipment or methods shall include evidence of improved performance, operational advantage, and maintenance enhancement over the equipment or method indicated, or shall include evidence that an indicated component is not available.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Refer to the requirements of Division 01 for additional requirements.

- B. Shipping

- 1. After completion of shop assembly, factory test, and approval, the tested I&CS equipment, cabinets, panels, and computer hardware shall be packed in protective crates and enclosed in heavy duty polyethylene envelopes or secured sheeting to provide complete protection from damage, dust, and moisture. Dehumidifiers shall be placed inside the polyethylene coverings. The equipment shall then be skid-mounted for final transport. Lifting rings shall be provided for moving without removing protective covering. Boxed weight shall be shown on shipping tags together with instructions for unloading, transporting, storing, and handling at the Site.

- C. Special Instructions

- 1. Special instructions for proper field handling, storage, and installation required by the manufacturer shall be securely attached to each piece of equipment prior to packaging and shipment.

- D. Tagging

- 1. A permanent stainless steel or other non-corrosive material tag marked with the instrument or equipment tag number shall be provided on each piece of equipment in the I&CS. Identification shall be prominently displayed on the outside of the package.

- E. Storage

- 1. It is the CONTRACTOR's responsibility to assure proper handling and on-site storage of instrumentation and control equipment in accordance with the System Supplier's recommendations. All equipment and materials delivered to the jobsite shall be stored in a location which will not interfere with the operations of other contractors or the OWNER. Equipment shall not be stored outdoors. Storage and handling will be performed in manners which will afford maximum protection to the equipment and materials.
 - 2. Equipment shall be stored in dry shelters, including in-line equipment, and shall be adequately protected against mechanical damage. If any apparatus has been damaged, such damage shall be repaired by the CONTRACTOR. If any apparatus has been subject to possible damage by water, it shall be thoroughly dried out and put through tests as directed by the ENGINEER. If such tests reveal defects, the equipment shall be replaced.

3.02 PRODUCT HANDLING

- A. Use all means necessary to protect the installation and to protect products and installed work of all other trades.

- B. Any damage to the products and/or installed work shall be repaired or replaced by the contractor, to the satisfaction of the OWNER and ENGINEER, at no additional cost to the OWNER.

3.03 INSTALLATION

- A. All systems and instrumentation, including instrumentation furnished under other Divisions, shall be installed, connected calibrated, tested, started, and placed into operation in accordance with CONTRACT documents under Division 17 and the manufacturers' instructions. The installation shall be coordinated with the ENGINEER and the OWNER. This shall include final integration in concert with equipment specified and provided by others.
- B. The CONTRACTOR shall employ installers who are skilled and experienced in the installation and connection of all I&CS equipment.
- C. Equipment Locations: The monitoring and control system configurations indicated in the contract documents are diagrammatic. The exact locations and routing of wiring and cables shall be governed by structural conditions and physical interferences and by the location of electrical terminations on equipment. Equipment shall be located and installed so that it will be readily accessible for operation and maintenance. Where job conditions require reasonable changes in approximated locations and arrangements, or when the OWNER exercises the right to require changes in location of equipment which do not impact material quantities or cause material rework, the CONTRACTOR shall make such changes without additional cost to the OWNER.
- D. The CONTRACTOR shall 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.
- E. The Contract Documents identify conduits and instruments required to make a complete I&CS. The CONTRACTOR shall be responsible for providing any reasonable additional or different type connections as required by parts of the I&CS' specific installation requirements, or as practical.

3.04 CONDUIT, CABLES, AND FIELD WIRING

- A. Conduits, process equipment control wiring, 4 to 20 mA signal circuits, signal wiring to field instruments and to control panels, PLC input and output wiring, and other field wiring and cables shall be provided under Division 16 and without delay to the WORK of Division 17.
- B. PLC equipment cables shall be provided under Division 17, but the installation in the field shall be under Division 16.
- C. Terminations and wire identification inside I&CS equipment and panels furnished under this or any other Division shall be provided under Division 17.
- D. The CONTRACTOR shall supervise and coordinate installation and termination and identification of field signals, power, and utilities associated with the I&CS. Resolve signal, power, or functional incompatibilities between the I&CS and new and existing interfacing devices.

3.05 EQUIPMENT CONNECTIONS AND INSTALLATIONS

- A. Instruments, control panels, and equipment shall be anchored by methods that comply with seismic requirements applicable to the Site. Appropriate mounting stands and bracket materials and workmanship shall be provided and shall comply with requirements of the Contract Documents.
- B. Existing Instruments that are to be removed and reinstalled shall be cleaned, reconditioned, and recalibrated by an authorized service facility of the instrument manufacturer. The CONTRACTOR shall provide certification of this WORK prior to reinstallation of each instrument.
- C. The Contract Documents show necessary conduit and instruments required to make a complete instrumentation. The CONTRACTOR shall be responsible for providing any additional or

different type connections as required by the instruments and specific installation requirements. Such additions and such changes, including the proposed method of installation, shall be submitted to the ENGINEER for approval prior to commencing that WORK. Such changes shall not be a basis of claims for extra WORK or delay.

- D. Field Connection Panels and Interface Terminal Blocks: In cases where field I/O wiring has to be extended to a control panel or from enclosures or devices that are removed, the CONTRACTOR shall provide separate enclosures or junction boxes with interface terminal blocks that will serve as a field connection panel (FCP). The FCP and the terminal block shall be shown on the project-wide wiring diagrams.
- E. Conduits and/or raceways in building interior locations shall be surface mounted on walls or ceilings wherever possible and run perpendicular and parallel to building lines. Conduits shall not be routed on floors in areas subject to foot traffic. In exterior locations conduit shall be routed below grade.
- F. Wires and cables shall be arranged in a neat manner and securely supported in cable groups and connected from terminal to terminal without splices unless specifically approved by the ENGINEER. Wiring shall be protected from sharp edges and corners.
- G. Signal and 24VDC low voltage wiring shall be run in a separate conduit from power and 120-volt control wiring.
- H. Field wiring shall terminate at terminal blocks in the control panel. Field wiring shall not be wired directly to equipment in the control panel except communication and specialty cables that must be wired directly to their respective equipment.
- I. Wires shall be marked clearly with an identification wire number labels that are of a permanent nature.
- J. Connectors shall be, as a minimum, water tight.
- K. Flexible cables and capillary tubing shall be installed in flexible conduits. The lengths shall be sufficient to withdraw the element for periodic maintenance.
- L. Differential pressure elements shall have 3 valve manifolds.
- M. The CONTRACTOR shall verify the correctness of each installation, including polarity of electric power and signal connections. The CONTRACTOR shall certify in writing all discrepancies have been corrected for each loop or system checked out. In addition, the CONTRACTOR shall make sure process connections are free of leaks.

3.06 SEALING OF WALL AND FLOOR OPENINGS

- A. The CONTRACTOR shall seal all conduit and cable entries passing through outside walls of buildings, through partition walls separating electrical rooms from other areas, through fire separations, and through floors above grade.
- B. Sealing material shall be fire resistant and not contain any compounds which will chemically affect the wiring jacket or insulating material. Cable penetrations through fire separations, if required, are to be sealed. Acceptable methods are Canstrut "Fire Stop", Electrovert "Multi-Cable Transit" or Dow Corning RTV Silicone Foam.
- C. Cable transit blocks (with knock out blocks) are also acceptable as long as they have capability to be sealed.

3.07 SLEEVES

- A. Provide sleeves of galvanized steel pipe with machine cut ends of ample size to accommodate conduits passing through walls, partitions, ceilings, floors, etc.
- B. For wall, partitions and ceilings the sleeve ends are to be flush with the finish on both sides. For floors the ends shall extend 4" above finished floor level.

- C. Fill the space between the sleeve and the conduit with fire stop material and caulked around the top and bottom with approved permanently resilient, non-flammable and weatherproof silicone base compound. Ensure that the seal is compatible with the floor and ceiling finishes.
- D. Locate the sleeves and position exactly prior to construction of the walls and floors.
- E. Failure to comply with the above requirements shall be remedied at the Contractor's expense.

3.08 TAGGING STANDARDS FOR DEVICES AND WIRING

- A. Tag all devices, wires and I/O using the assigned loop, equipment or device tag name. Where tag naming and numbering is not defined, the Engineer will provide naming and numbering that is consistent with the plant naming conventions.

3.09 FIELD QUALITY CONTROL

- A. Devices provided under Division 17 shall be initially calibrated by the manufacturer at the manufacturer's facility prior to shipment. Following installation, the devices shall be field calibrated according to the manufacturer's recommended procedures to verify operational readiness and ability to meet the indicated functional and tolerance requirements.
- B. Each instrument shall be field tested, inspected, and adjusted to the indicated performance requirement in accordance its manufacturer's specifications and instructions. Any instrument which fails to meet any contract requirement, or, in the absence of a contract requirement, any published manufacturer performance specification for functional and operational parameters, shall be repaired or replaced, at the discretion of the ENGINEER.
- C. Calibration Points: During bench and field calibration each instrument shall be calibrated at least at 0, 25, 50, 75, and 100 percent of span using test instruments to simulate inputs and outputs. The test instruments shall have accuracies traceable to National Institute of Standards and Testing.
- D. Bench Calibration: Instruments that have been bench-calibrated by the manufacturer shall be verified in the field after installation to determine whether any of the calibrations are in need of adjustment.
- E. Field Calibration: Instruments which were not bench-calibrated shall be calibrated in the field to insure proper operation in accordance with the instrument loop diagrams or specification data sheets.
- F. Analyzer Calibration: Each analyzer system shall be calibrated and tested as a workable system after installation. Testing procedures shall be directed by the manufacturers' technical representatives. Samples and sample gases shall be furnished by the manufacturers.
- G. Calibration Sheets: Each instrument calibration sheet shall provide the following information and a space for sign-off on individual items and on the completed unit:
 - 1. Project name
 - 2. Loop number and site or process name and number
 - 3. Tag number
 - 4. Manufacturer
 - 5. Model number
 - 6. Serial number
 - 7. Calibration range
 - 8. Calibration data: Input, output, and error at 0 percent, 50 percent, and 100 percent of span
 - 9. Switch setting, contact action, and dead-band for discrete elements
 - 10. Space for comments

11. Space for sign-off by System Supplier and when applicable by the manufacturer and date
 12. Test equipment used and associated serial numbers
 13. Calibration Tags: A calibration and testing tag shall be attached to each piece of equipment or system at a location determined by the ENGINEER. The CONTRACTOR shall have the System Supplier sign the calibration sheet when calibration is complete. The ENGINEER will sign the calibration sheet when the calibration and testing has been accepted.
 14. Loop Testing: The Contractor shall test newly installed loops for continuity and functionality. The up-to-date wiring diagrams shall be used as reference. The ENGINEER and/or the OWNER shall witness the loop testing.
- H. The CONTRACTOR shall notify the ENGINEER of scheduled tests minimum of 30 calendar days prior to the estimated completion date of installation and wiring of the I&CS. After the ENGINEER's review of the submitted loop diagrams for correctness and compliance with the specifications, loop testing shall proceed. The loop testing shall be witnessed by the ENGINEER and/or the OWNER.
- I. Control Valve Tests: Control valves, cylinders, drives and connecting linkages shall be stroked from the operator interface units as well as local control devices and adjusted to verify proper control action, hand switch action, limit switch settings, torque settings, remote control actions, and remote feedback of valve status and position. Control valve actions and positioner settings shall be checked with the valves in place to insure that no changes have occurred since the bench calibration.
- J. Interlocks: Hardware and software interlocks between the instrumentation and the motor control circuits, control circuits of variable-speed controllers, and packaged equipment controls shall be checked to the maximum extent possible.
- K. Loop Validation:
1. Control loops shall be checked under simulated operating conditions by impressing input signals at the primary control elements and observing appropriate responses of the respective control and monitoring elements, final control elements, and the HMI displays associated with the PLC or DCS. Actual signals shall be used wherever available. Following any necessary corrections, the loops shall be retested.
 2. Accuracy tolerances for each analog network are defined as the root-mean-square (RMS) summation of individual component accuracy requirements. Individual component accuracy requirements shall be as indicated by contract requirements or by published manufacturer accuracy specifications, whenever contract accuracy requirements are not indicated. Each analog loop shall be tested by applying simulated analog or discrete inputs to the first element of an analog loop. For loops which incorporate analog elements, simulated sensor inputs corresponding to 0, 25, 50, 75, and 100 percent of span shall be applied, and the resulting element outputs monitored to verify compliance to calculated RMS summation accuracy tolerance requirements. Continuously variable analog inputs shall be applied to verify the proper operation and setting of discrete devices. Provisional settings shall be made on controllers and alarms during analog loop tests. Analog loop test data, including calculated RMS summation system accuracy tolerance, shall be documented by the CONTRACTOR on the loop validation sheets. The validation sheets shall be included in the O&M Manuals.
- L. Loop Validation and Certification Sheets:
1. Loop Validation: The CONTRACTOR shall prepare loop validation sheets for each loop covering each active instrumentation and control device except simple hand switches and lights. Loop validation sheets shall form the basis for operational tests and documentation.

Each loop validation sheet shall cite the following information and shall provide spaces for sign-off on individual items and on the complete loop by the System Supplier:

- a. Project name
 - b. Loop number
 - c. Tag number, description, manufacturer, and model number for each element
 - d. Installation bulletin number
 - e. Specification sheet number
 - f. Loop description number
 - g. Adjustment check
 - h. Space for comments
 - i. Space for loop sign-off by the System Supplier and date
 - j. Space for ENGINEER witness signature and date
2. Loop Certification: A certified copy of each loop test validation sheet signed by the System Supplier, the ENGINEER or the ENGINEER's representative as a witness, with test data entered, shall be submitted to the ENGINEER together with a clear and unequivocal statement that the loops have been tested and the instrumentation in the loop has been successfully calibrated, inspected, and tested.

M. Manufacturer's Services

1. The CONTRACTOR shall provide jobsite visits and services of a manufacturer's technical field representative for supervision of the following:
 - a. Oversee installation: Supervise installation and connection of all instruments, elements, and components of every system, including connection of instrument signals to primary measurement elements and to final control elements such as VFD, smart starters, pumps, valves, engines and chemical feeders
 - b. Verify that installed instrument and software meet manufacturer's recommendations
 - c. Certify installation and reconfirm manufacturer's accuracy statement
 - d. Oversee loop testing, prepare loop validation sheets, and certify loop testing
 - e. Certify when testing is completed.
 - f. Training the OWNER's personnel

3.10 OPERATIONAL VALIDATION

- A. Where feasible, system pre-commissioning activities shall include the use of the actual process to establish service conditions that simulate, to the greatest extent possible, normal final control element operating conditions in terms of applied process loads, operating ranges, and environmental conditions. Final control elements, PLCs, control panels, and ancillary equipment shall be tested under startup and steady state operating conditions to verify that proper and stable control is achieved using motor control center and local field mounted control circuits. Hardwired and software control circuit interlocks and alarms shall be operational.
- B. The control of final control elements and ancillary equipment shall be tested using both manual and automatic (where provided) control circuits. The stable steady state operation of final control elements running under the control of process controllers shall be assured by adjusting the controllers as required to eliminate oscillatory final control element operation. The transient stability of final control elements operating under the control of controllers shall be verified by applying control signal disturbances, monitoring the amplitude and decay rate of control

parameter oscillations (if any), and making necessary controller adjustments as required to eliminate excessive oscillatory amplitudes and decay rates.

- C. Pre-commissioning shall also include the testing of remote sites to verify compliance with all functional requirements and communication specified. The testing shall include manual and automatic control modes, fail-safe and backup control modes, and PLC interlocks and control strategies provided by the System Supplier.
- D. Loop and Equipment Tuning: Controllers incorporating proportional, integral and/or derivative control circuits shall be optimally tuned, experimentally, by applying control signal disturbances and adjusting the gain, reset, or rate settings as required to achieve a proper response. Measured final control element variable position/speed set point settings shall be compared to measured final control element position/speed values at 0, 25, 50, 75, and 100 percent of span and the results checked against indicated accuracy tolerances.
- E. Pre-commissioning Validation Sheets: Pre-commissioning shall be documented on test forms as follows:
- F. The validation form, which shall include:
 - a. Project name
 - b. Loop number
 - c. Loop and function description
 - d. Tag number, description, manufacturer, and data sheet number for each component.
 - e. Pre-Commissioning Certification - A statement certifying that the contract requirements have been met. It shall also include a listing of instrumentation and control system maintenance and repair activities conducted during the pre-commissioning testing. Acceptance of the instrumentation and control system testing must be provided in writing by the ENGINEER before the performance testing may begin. Final acceptance of the control system shall be based upon plant completion as stated in the General Conditions.
 - f. Space for sign-off and date by the CONTRACTOR, the System Supplier, and the ENGINEER.

3.11 COMMISSIONING

- A. Commissioning is the verification that the complete WORK functions on an extended basis are in full conformance with the Contract requirements.
- B. As part of the commissioning, the entire I&CS shall operate continuously without failure for 30 consecutive days without failure (see test details below), thus extending its operation test longer than the commissioning period specified in Division 01.
- C. Refer to the requirements of Division 01 for additional commissioning requirements.
- D. The CONTRACTOR shall submit a report/letter states that CONTRACT requirements have been met and the I&CS is ready (2) weeks prior to energizing any system to allow inspections by ENGINEER.
- E. The entire I&CS shall go through a final 30-day acceptance test. For the purpose of this CONTRACT, the terms "Final Acceptance Test" and "Final Performance Test" are synonymous and are used interchangeably. The 30-day test must be successfully completed prior to the date of and as a condition to substantial completion of the entire project WORK. During the testing period, all system functions shall be exercised, and any system interruption and accompanying component, subsystem, software, or program failure shall be logged for cause of failure, as well as time of occurrence and duration of each failure.

- F. In addition to the requirements of Division 01, the CONTRACTOR shall furnish support staff as required to operate the system and to satisfy the repair or replacement requirements. The CONTRACTOR shall also provide a competently programmer on call during all normal working days and hours from the start of the acceptance test until final acceptance of the system. The on-call programmers shall be ready to respond within two hours of the notification of the problem.
- G. Testing
1. The entire I&CS shall be tested and shall include, but not limited to the following:
 - a. Verify instrument calibration and provide written report.
 - b. Verify signal levels and wiring connections to control panels for all instrumentation and control equipment.
 - c. Function check and adjust under operational conditions the instruments and control equipment.
 - d. Coordinate instruments and control equipment supplier's service personnel as required for complete system testing.
 - e. The CONTRACTOR shall make provision to be available and coordinate with the Plant Control System programming team, and the commissioning team to check the sensor signals from source to destination.
 - f. Instruct plant personnel in correct method of operation of instruments and control equipment.
 - g. Direct plant personnel at hand-over as to final adjustment of the system for correct operation of plant.
- H. Failure During Testing: Failure of the system during the testing shall be considered as indicating that part of the I&CS does not meet the requirements of the specifications and corrective action shall be required before restarting the acceptance test.
- I. Technician Report: Each time a technician is required to respond to a malfunction in the I&CS he/she must complete a report which shall include details concerning the nature of the complaint or malfunction and the resulting repair action required and taken. If a malfunction occurs which clears itself or which the operator on duty is able to correct, no report shall be required (logged as specified above). Each report shall be submitted within 24 hours to the ENGINEER or its representative, and the OWNER.

3.12 TRAINING

- A. The CONTRACTOR shall train the OWNER'S personnel on the I&CS operation, maintenance, calibration, and repair of equipment provided under this Contract. The training shall be by qualified instructors. The training courses shall be given on-site to a minimum of Four (4) people of the OWNER's personnel. All instruction, tools and training material shall be provided by the CONTRACTOR.
- B. These courses shall be designed to provide the operations, maintenance and supervisory personnel with training in routine and preventive maintenance of all the I&CS including instrumentation. The training course shall include instruction on the use of all maintenance equipment and special tools provided under the contract.
- C. Instructions
1. The training shall be performed by qualified instructors. The training shall be performed by qualified representatives of the equipment manufacturers and shall be specific to each piece of equipment.
- D. Training Manuals and Material

1. The CONTRACTOR shall use the approved Training syllabus and Training Manuals to develop training material. The training material shall be designed to provide the operations, maintenance and supervisory personnel with training in routine operation procedures, and preventive maintenance and troubleshooting of the I&CS, PLCs and the computer monitoring and control systems.

E. Schedule

1. Training shall be performed on-site during the calibration, loop and functional testing of the I&CS prior to the 30-day Final Acceptance Test. The training sessions shall be scheduled a minimum of 3 weeks in advance of when the courses are to be initiated. The ENGINEER will review the course outline for suitability and provide comments that shall be incorporated. Due to availability and scheduling of the OWNER's staff, the CONTRACTOR shall coordinate with the OWNER the schedule of the classes. The OWNER reserves the right to videotape the training sessions for later use. Due to possible limited availability of the OWNER's staff, the CONTRACTOR shall provide the number of identical courses/sessions of each of the following training courses as indicated, each up to four (4) people of the OWNER's staff.

- F. Training Subjects, Duration, and Agenda: The training shall include operation and maintenance procedures, troubleshooting with necessary test equipment, and changing set points, and calibration for that specific piece of equipment. During the course, hands-on experience with the system equipment shall be provided. Maintenance classes shall stress troubleshooting, repair, calibration, and other technical aspects of the I&CS and the PLCs. Operator classes shall stress operational theory and use of the I&CS and the PLCs.

1. Field Instruments

- a. Duration – an average of two (2) hours per each type of instrument
- b. Subjects - installation, setup, configuration, maintenance, calibration, and troubleshooting:
 - Level device and switches
 - Flow measuring device and transmitter

END OF SECTION

C. The magnetic flow metering system shall include a metering tube, transmitter, and signal cable and flowmeter grounding rings.

1. Metering Sensor/Tube:

- a. The metering sensor shall employ a pulsed DC technique to drive flux-producing coils. Sensors using high pulsed DC signals shall be used in accordance with the manufacturer's recommendations for the required service application and as indicated in the data sheet.
- b. The metering tube sizes shall be available from at least 1-inch to 48-inch line size. It shall be sized in accordance with the installation application and the intended service and as recommended by the manufacturer, and as indicated in the data sheet. If fractional size or larger size meters are required, the manufacturer shall be consulted for availability.

c. Metering Sensor/Tube

- Flanged Connections: The flanges' size, style, type and construction material shall be in accordance with the required installation and the intended service application and as recommended by the manufacturer, and as indicated in the data sheet. Pressure ratings shall be as indicated in the data sheet and in accordance with the requirements of process, as recommended by the manufacturer for the intended service.
- A minimum of two (2) electrodes shall be provided. The electrodes' material shall be suitable for the required service as recommended by the manufacturer, and as indicated in the data sheet. A reference electrode shall be provided as recommended by the manufacturer for the required installation application.
- Lining material shall be in accordance with the manufacturer's recommendation for the intended service, and as indicated in the data sheet.
- Meter housing shall be rated for NEMA 6P (IP68) (limited depth) and shall be offered with certified ratings for different hazardous locations as specified in the data sheet. It shall be able to operate between -20 to 140 Degrees F (-29 to 60 degrees C).
- Meter tube shall have epoxy protective coating.
- Grounding rings shall be provided and designed to protect and shield the liner's edge interface from abrasion at the meter end. Grounding rings shall conform to the manufacturer's bore and material recommendation for the intended service. Grounding shall conform to the manufacturer's recommendations.

2. Transmitter/Converter

- a. The transmitter/converter shall be capable of being mounted integral to the metering tube or remotely as indicated in the data sheet. Mounting hardware shall be provided. Refer to CONTRACT drawings for Transmitter/Converter mounting requirements.
- b. The transmitter/converter shall be rated for NEMA 4X (IP67). Certified ratings for different hazardous locations shall be offered as an option as specified in the data sheet. It shall be able to operate in ambient temperatures of -20 to 140 degrees F (-29 to 60 degrees C).

- c. The transmitter shall convert the DC pulse signal from the metering tube to a linear 4 to 20 mA DC signal into a minimum of 700 ohms. The 4-20 mADC signal shall comply with HART protocol. Output signal shall be continuously adjustable over the full scale. Other digital outputs options shall be available.
- d. The transmitter shall have an LCD displays for flow rate, percent of span, totalization, operator configuration interface, and diagnostic information.
- e. The transmitter shall have an adjustable integral low flow cutoff and zero return.
- f. The transmitter shall perform self-diagnostics and automatic data checking and activate a switch closure output when a transmitter fault is detected.

3. Cables

- a. Remote transmitter configuration shall be provided with the required lengths and types of electrodes and coil drive cables as recommended by the manufacturer for the required installation application. Maximum distance of transmitter from the metering tube shall be as recommended by the manufacturer.
- D. Calibration: Each flow metering system shall be hydraulically calibrated at a facility that is traceable to the National Institute of Standards and Technologies. The calibration procedure shall conform to the requirements of ANSI/NCSL Z 540-1 Calibration. A real-time computer generated printout of the actual calibration data shall be submitted to the ENGINEER at least 30 Days prior to shipment to the site.

PART 3 - EXECUTION

3.01 FIELD QUALITY CONTROL

- A. In-line liquid flow measuring systems shall be handled, installed, calibrated, loop-tested, pre-commissioned, and performance tested in accordance with Section 17010 – Instrumentation and Process Control Systems.
- B. Manufacturer's service, supervision, and training shall also be in accordance with Section 17010 – Instrumentation and Process Control Systems.

END OF SECTION

SECTION 17707 LEVEL DETECTION

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. General: The CONTRACTOR shall provide level detection switches, complete and operable, in accordance with the Contract Documents.

1.02 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. Section 17010 – Instrumentation and Process Control Systems.
- B. Division 16 – Electrical.

1.03 SUBMITTALS

- A. Submittals shall be provided in accordance with the requirements specified in Section 17010 – Instrumentation and Process Control Systems.

PART 2 - PRODUCTS

2.01 FLOAT TYPE LEVEL SWITCHES

- A. Manufacturers: Float type level switch manufacturers shall be **MJK 7030**, or Approved Equal.
- B. Description: Tipping float level switch shall consist of a switch, a moving float, and a connecting cable that is anchored at the midpoint of a differential band. As the level rises and falls the float rights itself or inverts causing switching actions. The cable anchoring point shall be protected by strain relief.
- C. Performance / Design Criteria: The hermetically sealed switches shall have a SPDT output with a minimum rating of 10 Amps at 120 VAC.
- D. Materials / Components: The float switch shall be mercury-free. Float material shall be in accordance with the manufacturer's recommendations for the intended service and installation application and as indicated in the data sheet.

PART 3 - EXECUTION

3.01 FIELD QUALITY CONTROL:

- A. Level detection switches shall be handled, installed, calibrated, loop-tested, pre-commissioned, and performance tested in accordance with Section 17010 – Instrumentation and Process Control Systems. Manufacturer's service, supervision, and training shall also be in accordance with Section 17010 – Instrumentation and Process Control Systems.

END OF SECTION