CITY OF PHOENIX
WATER SERVICES DEPARTMENT

LIFT STATION NO. 66 REFURBISHMENT
INDEX NO. WS90400084

TECHNICAL SPECIFICATIONS
DIVISION 01 THROUGH DIVISION 17
VOLUME 1

FINAL SUBMITTAL

MAY 2023

CITY OF PHOENIX
WATER SERVICES DEPARTMENT
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Registered Professional Engineer (Civil) CERTIFICATE NO. 60517 JONATHON CHILL Date Signed 5/10/23 ARIZONA, U.S.A

Registered Professional Engineer (Civil) CERTIFICATE NO. 70373 HARRY W. ELLIOTT

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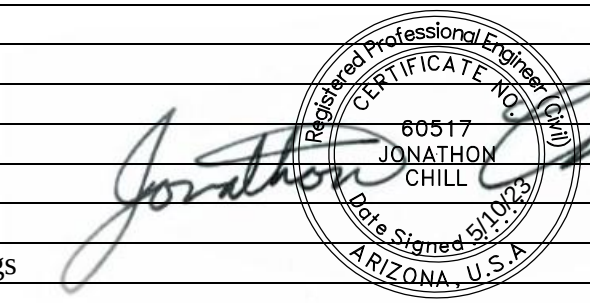

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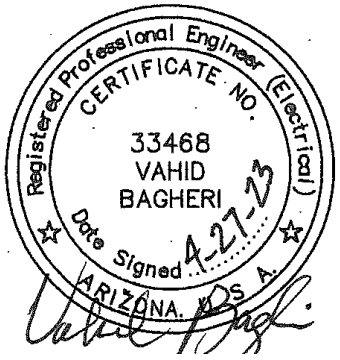

SECTION 01110

SUMMARY OF WORK

PART 1 - GENERAL

1.1 LOCATION AND DESCRIPTION OF WORK

A. The Work is located on the site of the Lift Station No. 66 at the following address:
   1. 30200 N Black Canyon Hwy
      Phoenix, AZ 85085

B. The Contract Documents include the following:
   1. Volume 1 of 3 General Conditions
   3. Volume 2 of 3 Drawings
   2. Volume 3 of 3 Divisions 1 Through 17 Specifications

C. The Contract Documents for the Work to be performed include the following, but are not limited to:
   1. Demolition of existing lift station pumps, piping, valves, pipe supports, handrail, electrical, instrumentation, control panels and electrical facilities as indicated.
   2. Temporary bypass pumping during demolition and new construction as required.
   3. Installation of new pumps, piping, valves, pipe supports, hatches instrumentation and control panels.
   4. Replacement of wet well sluice gates.
   5. Modifications to wet well including new lining.
   6. Replacement of existing PLC and autodialer alarms.
   7. Concrete repair, as required, at chemical containment areas.
   8. Recoating of chemical containment areas.
   9. Improvements to site grading to alleviate flooding at Electrical Building.
   10. Replacement of existing chemical odor control system with a new packaged biofilter system.
   11. Civil yard piping as well as paving and grading modifications.

D. Hazardous Environmental Condition: The responsibility for clean-up of Hazardous Environmental Conditions, in which conditions are described in reports referenced in the Supplementary Conditions, is within the Scope of Work, belongs to CONTRACTOR and shall be coordinated with the General Conditions, Supplementary Conditions and Section 01413, CONTRACTOR'S Hazardous Materials Management Program.

1.2 CONTRACT

A. The Work shall be constructed under one prime contract.

1.3 OTHER CONSTRUCTION CONTRACTS

A. Other construction contracts have been or will be awarded by the OWNER that are in close proximity to or border on the Work of this Contract. The CONTRACTOR must complete the Work and coordinate sequencing, shutdowns, and commissioning with the contracts:
   1. Lift Station No. 66 Independent Electrical Feed

1.4 WORK BY OWNER

A. OWNER will perform the following:
   1. Operation of all existing system gates, valves and equipment, unless specified otherwise.

1.5 OWNER-FURNISHED EQUIPMENT AND MATERIALS

A. The items of equipment and materials to be furnished by OWNER for installation by CONTRACTOR are described in Section 01610, Pre-Purchased Equipment Coordination and listed below:
   1. Submersible Pumps.
   2. Large Diameter Valves.
   3. Variable Frequency Drives.

B. Delivery of OWNER-furnished Equipment and Materials:
   1. Not applicable.

C. Specifications under which the equipment and materials were procured are available for inspection at:
   1. Approved submittals are available from the ENGINEER.

D. CONTRACTOR shall keep ENGINEER and OWNER informed of probable delivery date(s) of equipment and materials.

E. OWNER'S Responsibilities:
   1. Arrange for and deliver OWNER'S approved Shop Drawings, product data, and Samples to CONTRACTOR.
   2. Coordinate delivery date with CONTRACTOR 14 days prior to scheduled delivery.
   3. Arrange and pay for delivery to site.
   4. On delivery, inspect jointly with CONTRACTOR.
   5. Submit claims for transportation damage and replace damaged, defective, or deficient items of equipment and materials.
   6. Provide the services of a factory-trained representative of the equipment manufacturer to provide consultation and advice during the installation of the equipment, to inspect, check and approve the installation before operation, and to provide technical direction during the start-up and testing of the equipment.

The extent to which the services of the factory-trained representative will be provided during installation will be determined by OWNER.

7. Arrange for: manufacturers' warranties, inspections, and services.

F. CONTRACTOR'S Responsibilities:
   1. Responsibilities for equipment and materials delivered for the Work will begin on CONTRACTOR'S acceptance of the equipment and materials at that location.
   2. Receive and unload equipment and materials at site. Provide all labor and equipment for unloading. Perform unloading promptly. All charges for demurrage due to negligence or delay shall be paid by CONTRACTOR.
   3. Inspect for completeness or damage, jointly with OWNER, and reject all defective items. OWNER, however, reserves the right to accept items rejected by CONTRACTOR and to authorize their use in the Work.
   4. Indicate to OWNER signed acceptance of delivery on a copy of the shipping invoice.
   5. Increase property insurance specified in the General Conditions to reflect replacement value of the OWNER furnished equipment and materials.
   6. Handle, store, and maintain equipment and materials.
   7. Repair or replace equipment and materials which are missing or lost or are damaged after receipt. Replacements shall conform to OWNER'S original procurement specifications.
   8. Provide Shop Drawings, Submittals per Section 01330 – Submittals), and Samples per Section 01333-Samples.
   9. Install, connect, and startup in accordance with manufacturer's instructions, unless otherwise specified.

1.6 ASSIGNED PROCUREMENT CONTRACTS

A. Contracts for the procurement of products described in this Paragraph will be assigned to CONTRACTOR as specified in the Agreement and are listed below:
   1. Not applicable.

1.7 SEQUENCE AND PROGRESS OF WORK

A. Submit a Construction Schedule covering the entire Work in accordance with Section 01321 - Progress Schedule - CPM.

B. Incorporate the requirements of Section 01111, Schedule of Completion, and Section 01143, Coordination with OWNER'S Operations, into the Construction Schedule. CONTRACTOR'S construction schedule may use a different sequence from that shown or specified, if techniques and methods known will result in cost and time savings to the OWNER, still achieve the required objective and maintain the same or greater level of treatment. The ENGINEER'S determination on the acceptability of any alternative sequence from that shown or specified shall be final.

C. CONTRACTOR: The project electric motor requirements, specified in Section 11000, Electric Motors, do not allow standard "off the shelf" motors. Make provisions in sequence and progress of Work to account for longer manufacturing and delivery lead times for the motors and equipment requiring electric motors under this project.

1.8 CONTRACTOR'S USE OF PREMISES

A. Coordinate use of the premises, for his storage and the operations of his workmen, with OWNER, ENGINEER and utility service companies.

B. The full use of the premises for storage, the operations of workmen and for all other construction activities will not be available to CONTRACTOR. Must operate entirely within the space allowed to him.

C. Sole responsibility for obtaining and paying all costs in connection with any additional work area, storage sites, access to the site or temporary right-of-way which may be required for proper completion of the Work, belongs to CONTRACTOR.

D. It shall be understood that responsibility for protection and safe-keeping of equipment and materials on or near the site will be entirely that of CONTRACTOR and that no claim shall be made against the OWNER or his authorized representatives by reason of any act. It shall be further understood that should any occasion arise necessitating access to the sites occupied by these stored materials or equipment, the ENGINEER shall direct CONTRACTOR owning or responsible for the stored materials and equipment to immediately move the same. No materials or equipment may be placed upon the property of the OWNER, other than in the designated areas as shown on the Drawings, or as described in the specifications, unless the ENGINEER has agreed to the location contemplated by CONTRACTOR to be used for storage. All stored materials shall be labeled according to the appropriate contractor or subcontractor with the manufacturer's label as well. Appropriate material safety data sheets (e.g., MSDS) shall be provided.

D. Required to share use of the premises with other contractors whose services the OWNER has obtained or will obtain for construction of other facilities on the site.

1.9 EASEMENTS AND RIGHTS-OF-WAY

A. Easements and rights-of-way determined by the OWNER to be required to perform the Work will be provided by OWNER. Confine construction operations within the limits indicated on the Drawings. Use due care in placing construction tools, equipment, excavated materials, and pipeline materials and supplies in order to avoid damage to property and interference with traffic. Do not enter any private

property outside the designated construction easement boundaries without written permission from the ENGINEER and the owner of the property. Any private property or rights-of-way owned by other than the OWNER, which CONTRACTOR wishes to utilize during the performance of the Work, shall be provided by CONTRACTOR.

B. On Private Property: The CONTRACTOR shall coordinate access to private property as required to complete the Work. The following are known private properties that will require access:
   1. Not applicable.

C. Within Highway and Railroad Rights-of-Way: Permits will be obtained by CONTRACTOR. All Work performed and all operations of CONTRACTOR, its employees, or subcontractors within the limits of railroad and highway rights-of-way shall conform to the requirements and be under the control of the railroad or highway authority owning, or having jurisdiction over and control of, the right-of-way.

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

A. Notify owners of adjacent properties and utilities when prosecution of the Work may affect them.

B. When it is necessary to temporarily obstruct access to property, or when any utility service connection must be interrupted, give notices sufficiently in advance to enable the affected persons to provide for their needs. Conform notices to any applicable local ordinance and, whether delivered orally or in writing, include appropriate information concerning the interruption and instructions on how to limit inconvenience caused thereby.

C. Utilities and other concerned agencies shall be notified at least 72 hours prior to cutting or closing streets or other traffic areas or excavating near underground utilities or pole lines.

1.11 SALVAGE OF EQUIPMENT AND MATERIALS

A. Existing equipment and materials removed and demolished, and not shown or specified to be reused as a part of the Work, shall become CONTRACTOR'S property, except the following items which shall remain OWNER'S property:
   1. Demolished submersible pumps.
   2. Demolished valves.
   3. Demolished pipe fittings.
   4. Demolished control panels.

B. Existing equipment and materials removed by CONTRACTOR shall not be reused in the Work, except where so specified or indicated.

C. Carefully remove, in a manner to prevent damage, all equipment and materials specified or indicated to be salvaged and reused or to remain the property of OWNER. Store and protect salvaged items specified or indicated to be reused in the Work. Replace in kind or with new items any items damaged in removal, storage, or handling through carelessness or improper procedures.

D. Furnish and install new items, with ENGINEER'S approval, instead of those specified by OWNER or indicated to be salvaged and reused, in which case such removed items will become CONTRACTOR'S property.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 01111

SCHEDULE OF COMPLETION

PART 1 - GENERAL

1.1 DESCRIPTION

A. Commence the Work promptly upon the date established in the Notice to Proceed and shall pursue it to completion in accordance with the Agreement (Section 00500) as described in this Section.

B. The Schedule of Completion describes selected project components only and is not intended to describe all project Work or constraints, interrelationships, or sequentially required Work.

C. Completion of certain activities are directly related to treatment capacities at the Phoenix Lift Station 66. A Shutdown Schedule, consisting of all plant or facility shutdowns, is included in Section 01143, Coordination with OWNER'S Operations.

D. Contract times, as well as liquidated damages for failure to Substantially Complete the Schedule of Completion specified in this Section, are defined in the Agreement (Section 00500).

1.2 SCHEDULE OF COMPLETION

A. Submit Shop Drawings in accordance with Section 01332, Shop Drawing Procedures, and the individual specification Sections. Submit early Shop Drawings as noted and as required to meet the Schedule of Completion.

B. The Schedule of Completion for the Phoenix Lift Station 66 Refurbishment Project shall be as follows:

SCHEDULE OF COMPLETION	
Description	*Completion Calendar Days*
Substantial Completion	670 calendar days after Notice to Proceed
Final Completion	730 calendar days after Notice to Proceed

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 01140

WORK RESTRICTIONS

PART 1 - GENERAL

1.1 USE OF PREMISES

A. Limit use of premises to Work in areas indicated. Do not disturb portions of site beyond areas in which Work is indicated.
   1. Limits: Confine construction operations to designated areas indicated on the Drawings. Confine storage of materials and support facilities to designated areas indicated on the Drawings.
   2. Driveways and Entrances: At all times, keep driveways and entrances serving premises clear and available to OWNER, OWNER'S employees, and emergency vehicles. Coordinate with the requirements of Section 01550, Access Roads and Parking Areas. Do not use these areas for parking or storage of materials.
      a. Schedule deliveries to minimize use of driveways and entrances.
      b. Schedule deliveries to minimize space and time requirements for on-site storage of materials and equipment.

B. Use of Existing Building: Obtain OWNER'S written permission for each use of existing building.

C. Use of Existing Building: Maintain existing building in a weather-tight condition throughout construction period. Protect building and its occupants during construction.

D. Promptly repair damage to premises caused by construction operations. Upon completion of the Work, restore premises to original condition.

1.2 SUBMITTALS

A. The CONTRACTOR shall submit a written sequencing plan within 30 calendar days of any desired demolition, shutdowns, or tie-ins. The plan shall indicate details and durations for all proposed demolition, shutdowns, new construction, and temporary bypass pumping operations required to complete the Work. This includes mechanical demolition, electrical demolition, tie-ins to existing utilities, new pumping facilities, new electrical facilities, and new odor control facilities.

1.3 CONSTRAINTS ON SEQUENCE AND SCHEDULING OF WORK

A. Lift Station 66 is the OWNER's only means of conveying wastewater in the service area. Completing the Work in any way that impairs pumping capacity, routine

operation or shutdown may result in serious environmental damage and monetary fines that will be the responsibility of the CONTRACTOR.

B. The CONTRACTOR shall conduct work in a manner that will not impair the essential operation and pumping capability of Lift Station 66 and its associated facilities.

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PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 01143

COORDINATION WITH OWNER'S OPERATIONS

PART 1 - GENERAL

1.1 DESCRIPTION

A. The intent of this Section is to provide CONTRACTOR a sequence to perform the Work in such a manner that continuous, uninterrupted operation of Lift Station No 66 (Facility) and all essential Facility services and facilities are maintained operational throughout the construction period.

B. The sequences of Work and Schedule of Completion are specified under Section 01110, Summary of Work, and Section 01111, Schedule of Completion. The sequences have been assembled to maintain Facility operations during construction.

C. Except for the shutdown durations specified in this Section, CONTRACTOR'S means and methods shall be implemented such that the existing Facility, shall remain in continuous satisfactory operation during the entire construction period. Work shall be so scheduled and conducted by CONTRACTOR such that it shall not impede any treatment process, compromise Facility security, create potential hazards to operating equipment and Facility personnel, reduce the quality of the plant effluent or cause odor or other nuisances. In performing the Work shown and specified, plan and schedule the Work to meet both the constraints outlined in this Section and Facility operating requirements.

D. Work not specifically covered in Section 01110, Summary of Work; and Section 01111, Schedule of Completion or in the following paragraphs may, in general, be done at anytime during normal work hours during the Contract period, subject to the operating requirements outlined in this Section. All references to days in this Section are consecutive calendar days.

E. Any temporary facilities required to mitigate or eliminate a constraint shall be provided by the CONTRACTOR at no additional cost to the OWNER or ENGINEER and must present no safety hazards and also satisfy all requirements of these Specifications and Drawings.

F. The CONTRACTOR shall be responsible for coordinating all shutdowns with the OWNER and ENGINEER. Whenever possible, combine discrete shutdown procedures identified in this Section or by CONTRACTOR into a single shutdown when the duration of the shutdowns or the Work requirements allow such combining to occur on a unit process or work area. The intent of combining

procedures is to minimize the impacts upon Facility operations and processes by limiting the number of shutdowns required.

G. Do not shut-off or disconnect any operating system of the Facility, unless approved by the ENGINEER, in writing. All Facility equipment operations and shutdowns shall be executed by the OWNER, unless otherwise noted. Seal OWNER operated gates and valves to prevent unnecessary leakage. After CONTRACTOR'S Work has been completed, remove the seal to the satisfaction of the ENGINEER.

H. This Section of the Specifications contains several references to equipment, piping, material, and appurtenances to be removed or reinstalled. Refer to the Drawings, Section 02220, Demolitions, and other applicable Sections, for definition of the equipment, piping, material and appurtenances to be removed, turned over to the OWNER and stored on site, or to become the property of CONTRACTOR and removed from the site.

I. Responsible for supplying all temporary pipelines, valves, pumps, meters, spare parts, electrical, controls, any other appurtenances, and labor required for the installation and operation of temporary bypass lines, pumping systems, or conveyance systems required to maintain operations of the Facility during construction activities. All pumps shall be provided with magnetic flowmeters capable of providing a 4 to 20 mADC output signal. Man all pumps continuously (24 hours per day) when in service. Submit to the ENGINEER, for information only, the design for all temporary lines, pumping, or conveyance systems at least 14 days prior to the commencement of the Work.

J. Unless otherwise specified, dewater process tanks and pipelines at the beginning of each shutdown. Responsible for washing down and cleaning all tanks, basins, pipelines and other Work areas. Also for the removal of all washdown, cleaning and storm water that accumulates in the Work areas. Approximate depth of sludge, grit and other debris which can be expected to accumulate in the bottom of basins, wet wells, splitter structures and pipelines is 36-inches. The CONTRACTOR is responsible for removing this material and disposing of off site. Removal of material shall be included as a separate item on CONTRACTOR'S Schedule of Values.

1.2 GENERAL CONSTRAINTS

A. Article 1.3, below, and Section 01111, Schedule of Completion, specify the sequence and shutdown durations, where applicable, for Facility units which are to be taken out of service. The operational status of new or existing units other than the designated units shall not be interrupted by CONTRACTOR during the specified time periods. New units may only be used after the specified testing is completed and the units are accepted for use by the ENGINEER, in writing.

B. The following constraints shall be applied to all equipment and appurtenant utility systems on the Facility.
   1. Load limits on Access Roads: Existing and new underground facilities, such as electrical duct banks, pipelines, etc., in, under and crossing Facility roads, have been designed for a maximum wheel load of truck traffic per AASHTO HS-20 loading. The CONTRACTOR shall not exceed this weight limit and shall provide means of protecting the underground facilities.
   2. Access to Facility: An unobstructed traffic route through all Facility gates shall be maintained at all times.
   3. Safety Barriers: Place safety barriers around unsafe areas located around operational areas accessible to Facility Personnel.
   4. Personnel Access: Facility Personnel shall have access to all areas which remain in operation throughout the construction period.
   5. Potable Water System: The existing potable water system shall be kept in operation at all times, unless otherwise specified in Article 1.3, below.
   6. Plumbing Facilities: Sanitary facilities in the existing structures shall be operational at all times for Facility Personnel, unless otherwise specified in Article 1.5, below. All other building plumbing systems, such as roof and floor drains, pumping, etc., shall be maintained for all structures.
   7. Storm drainage: Storm drainage on the site shall be operational at all times, unless otherwise specified in Article 1.3, below.
   8. Building Heating and Ventilating: In CONTRACTOR'S Work areas and areas affected by CONTRACTOR'S operations, building heating and ventilating shall be both provided and maintained in structures, including pipe galleries. The temperatures to be maintained in any area occupied by Facility Personnel, such as offices, lunchrooms, locker rooms, toilet rooms, facilities containing computer control equipment, etc., shall be at least 65°F and not greater than 80°F. The temperatures to be maintained in all other interior Facility areas, whether new, existing or temporary, shall be maintained at a minimum of 55°F and not greater than 90°F.
   9. Power, Light and Communication Systems: Electric power, lighting service and communication systems shall be maintained in uninterrupted operation in all areas, unless otherwise specified in Article 1.3, below.
   10. Sump Pumps and Sumps: All existing sumps shall be maintained in an operable condition with either existing pumps or temporary pumps provided by CONTRACTOR. Interim piping, power and controls shall be provided by CONTRACTOR, as required by the construction sequence and as directed by the ENGINEER.
   11. Seal and Service Water Piping: A supply of service and seal water and the necessary connections to existing equipment shall be maintained during construction, unless otherwise specified in Article 1.3, below. Interim piping shall be provided by CONTRACTOR, as required.
   12. The OWNER will assist CONTRACTOR in dewatering process tanks, basins and other Facility Work areas. It is CONTRACTOR'S responsibility to

maintain a clean and dry Work area by pumping and properly disposing of all washdown and cleaning water and stormwater that accumulates in the Work areas.

13. Draining Process Pipes and Conduits:
    a. Unless otherwise specified, the contents of pipes and conduits undergoing modifications shall be transferred to the Lift Station 66 Influent Manhole using hoses, piping, pumps, existing drains, or other applicable means.
    b. If a drain is not available on the pipe to be drained, then a wet tap shall be made by CONTRACTOR using a tapping saddle and valve approved by the ENGINEER. No uncontrolled spillage of a pipe's contents shall be allowed.
    c. Any spillage shall be brought to the ENGINEER'S attention immediately in writing. Wash down any spillage to floor drains, sumps and sump pump discharge piping and then flush out the system to prevent clogging and septic odors. If spillage is not suitable for drainage system, e.g. chemical spills, etc, as determined by the ENGINEER, remove spillage by other method such as Vactor truck, as approved by the ENGINEER.
14. Temporary Partitions and Enclosures: Provide temporary partitions and enclosures necessary to maintain dust-free, heated and ventilated spaces in all areas which are adjacent to his Work and which must be kept operational.
15. Dead End Valves or Pipe: Provide blind flanges on all valves or pipes which dead-end a line on a temporary or permanent basis. Blind flanges shall be braced and blocked, as required or as directed by the ENGINEER in the field.
16. Schedule all start-ups for Monday through Thursday. No start-ups will be allowed on Friday, Saturday, and Sunday.

1.3 SHUTDOWNS

A. General:
    1. A shutdown shall be defined as a portion of the normal operation of a Facility unit or conduit that has to be suspended or taken out of service in order to perform the specified Work. For each shutdown, compile an inventory of labor and materials required to perform tasks, provide an estimate of the time required (including time for the OWNER to take down and start-up the Facility unit or conduit), and a written description of steps required to complete all tasks. All shutdown requests must be submitted in writing to the OWNER and ENGINEER for review and include the inventory, the estimate, and comprehensive written procedures. The shutdown request shall be submitted not less than 14 calendar days prior to the proposed start date of the shutdown. A secondary written shutdown request shall also be submitted to the OWNER and ENGINEER a minimum of 7 calendar days prior to the proposed shutdown date. No shutdown shall be initiated until the inventory of materials and labor is verified by the ENGINEER on site at least 1 week prior to the proposed start date.

2. The Work required herein and any other Work required by the ENGINEER which may interrupt the normal Facility operations shall be accomplished at such times that will be convenient to the OWNER.
3. Have on hand and located in close proximity to the Work area, all tools, equipment, spare parts and materials, both temporary and permanent, necessary to complete each Work category without interruption. Adequate numbers of personnel shall be scheduled for each shutdown, so that the Work shall be accomplished within the specified time frame. Prefabrication of all piping and other assemblies shall be completed, to the greatest degree possible, prior to any shutdowns. The ENGINEER shall be satisfied that CONTRACTOR has complied with these requirements, to the fullest extent possible, before shutdowns will be authorized.
4. If CONTRACTOR'S procedures cause an unscheduled shutdown of the facilities, perform Work as necessary to immediately re-establish satisfactory operation. Notify the ENGINEER, in writing, immediately of any unscheduled shutdown. If necessary, permit OWNER'S personnel to work with CONTRACTOR'S personnel, as required, to maintain the Facility in continuous satisfactory operation. Unscheduled shutdowns or interruptions of continued safe and satisfactory operation of the facilities that result in additional material, equipment and labor costs by the OWNER and/or ENGINEER as well as fines levied by the U.S. Environmental Protection Agency, Arizona Department of Environmental Quality, Maricopa County Health Department Bureau of Air Pollution Control, or the Maricopa County Department of Environmental Management shall be the responsibility of CONTRACTOR if it is demonstrated that CONTRACTOR was negligent in the Work or did not exercise proper precautions in the conduct of the Work.
5. The CONTRACTOR shall submit a list of scheduled shutdowns based on the specific schedule for completing the Work in a format per Table 01143-A. All Work requiring the Facility to be out-of-service shall be performed during the scheduled shutdowns shown. It should be noted Facility staff shall continue to perform administrative, operation and maintenance functions during shutdowns.
6. Electrical Ductbank Installation: Shutdown and relocation of conflicting utilities alignments with electrical ductbank will only be allowed for certain types of process pipelines. Any shutdown and relocations shall follow a strict time schedule in order to minimize impact to Facility operations.

B. Coordination with Prepurchased Equipment: The CONTRACTOR shall be responsible to schedule shutdowns based on delivery of all prepurchased equipment indicated in Section 01610, Coordination of Prepurchased Equipment.

C. Shutdowns of Electrical Systems: Lock out and tag circuit breakers and switches operated by the OWNER and shall check cables and wires to be sure that they are de-energized to ground potential before Work begins. Upon completion of the

Work, remove the locks and tags and notify the ENGINEER that the facilities are available for use.

1.4 OVERTIME

A. All overtime Work by CONTRACTOR necessary to conform to the requirements of this Section shall be performed by CONTRACTOR, at no additional cost to the OWNER and shall be performed in accordance with the General Conditions. Make no claims for extra compensation as a result thereof.

1.5 MAINTENANCE OF FACILITY OPERATIONS SCHEDULE

A. In order to maintain a continuous Facility operation during construction, a preliminary Maintenance of Facility Operations (MOFOs) Schedule with suggested procedures and a partial list of known constraints is included at the end of this Section.

B. Within each MOFO item's procedural steps, time and scheduling constraints and milestone dates may be outlined and are intended to assist CONTRACTOR in developing a sequence of Work and timing in order to maintain continuous operation of the Facility.

C. Develop a detailed written description of the complete sequence of construction for all the MOFO events contained herein. The written sequence shall be submitted to the OWNER and ENGINEER for review and approval 30 days following the Notice to Proceed.

D. The procedures contained herein were developed based upon available information. This list does not address all required tie-ins, but only those anticipated to be of significant impact to Facility operations.

E. Is required to make all tie-ins, connections, and replacements necessary to perform the Work.

F. Is advised that Work in multiple areas of the Facility, gravity sewer and force main system shall be performed simultaneously in order to complete the entire scope of the Work within the allotted Contract time.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION + +

1.0 (LIFT STATION 66).

ITEM NO./ DWG. NO.	ITEM DESCRIPTION	PROCESS UNITS OPERATING PRIOR TO SHUTDOWN	PROCESS UNITS OPERATING DURING SHUTDOWN	PROCESS UNITS OUT-OF-SERVICE DURING SHUTDOWN	IMPACT ON OTHER PROCESS UNITS	SUGGESTED PROCEDURE	CONSTRAINTS AND REMARKS	ESTIMATED DURATION OF SHUTDOWN
Phase 1A	P-101 valves changeout	N/A	Pumps P-102 and P-103 remain in service.	P-101 will be out of service	Number of available wastewater pumps will be two (2) instead of existing three (3). Flow capacity will be reduced. Compressed air connection to existing P-101 pneumatic plug valve will be cut and capped.	CONTRACTOR shall shut down and tag out Pump P-101, then remove Pump P-101 pneumatic plug valve and adjacent piping spools. During temporary outage, the isolation plug valve shall be removed. Contractor shall install proposed isolation plug valve as closed then re-pressurize discharge header. Contractor shall install proposed check valve and adjacent piping spools. Contractor shall return Pump P-101 to service.	P-101 isolation valve changeout must occur after existing western discharge header is depressurized and drained. Temporary bypass pumping may be required.	4-8 hours
Phase 1B	P-102 valves changeout	N/A	Pumps P-101 and P-103 remain in service.	P-102 will be out of service	Number of available wastewater pumps will be two (2) instead of existing three (3). Flow capacity will be reduced. Compressed air connection to existing P-102 pneumatic plug valve will be cut and capped.	CONTRACTOR shall shut down and tag out Pump P-102, then remove Pump P-102 pneumatic plug valve and adjacent piping spools. During temporary outage, the isolation plug valve shall be removed. Contractor shall install proposed isolation plug valve as closed then re-pressurize discharge header. Contractor shall install proposed check valve and adjacent piping spools. Contractor shall return Pump P-102 to service.	P-102 isolation valve changeout must occur after existing western discharge header is depressurized and drained. Temporary bypass pumping may be required.	4-8 hours

ITEM NO./ DWG. NO.	ITEM DESCRIPTION	PROCESS UNITS OPERATING PRIOR TO SHUTDOWN	PROCESS UNITS OPERATING DURING SHUTDOWN	PROCESS UNITS OUT-OF-SERVICE DURING SHUTDOWN	IMPACT ON OTHER PROCESS UNITS	SUGGESTED PROCEDURE	CONSTRAINTS AND REMARKS	ESTIMATED DURATION OF SHUTDOWN
Phase 1C	Install East Wet Well and West Wet Well Submersible Pump Electrical Ductbank and Local Control Panels.	Pumps P-101, P-102 and P-103 remain in service.	Pumps P-101, P-102 and P-103 remain in service.	None.	Potential impact to wastewater pumping capacity.	Route new electrical ductbanks, install new local control pumps, pull wire, and coordinate tie-ins to electrical and mechanical with other shutdowns.	Wastewater pumping shutdown may be required to make connections with mechanical and electrical. Temporary bypass pumping may be required.	2 – 8 hours
Phase 2	Air Equipment Demolition	N/A	Pumps P-101 and P-102 remain in service.	From this point forward, P-103 will be out of service due to lack of compressed air to operate pneumatic plug valve.	Number of available wastewater pumps will be two (2) instead of existing three (3). Flow capacity will be reduced. Compressed air connection to existing P-103 pneumatic plug valve will be cut and capped.	Contactor shall lock out and disconnect compressed air compressor, storage tank, control valves, and other compressed air appurtenances. Contractor shall demo all compressed air equipment	Wastewater pumping shutdown may be necessary to facilitate the disconnection of power to air equipment. Temporary bypass pumping may be required.	2 - 4 hours
Phase 3	Existing Discharge Manifold Demolition	N/A	Pumps P-101 and P-102 remain in service.	P-103 will be out of service due to lack of compressed air to operate pneumatic plug valve.	Number of available wastewater pumps will be two (2) instead of existing three (3). Flow capacity will be reduced. Compressed air connection to existing P-103 pneumatic plug valve will be cut and capped.	Contractor shall depressurize and dewater the discharge manifold. Contractor shall blind flange the tee to the existing discharge manifold. Contractor shall demo the existing discharge manifold.	Wastewater pumping shutdown may be necessary to facilitate installation of the blind flange. Temporary bypass pumping may be required.	1 – 2 days
Phase 4	Demolish Existing Slide Gates, Install New Slide Gates.	Slide gates SLUG-100A, SLUG-100B, SLUG-105. Submersible Pumps P-101, 102-103	None.	Submersible pumps P-101, P-102, P-103	Potential impact to wastewater pumping capacity.	Verify new slide gates SLUG-100A, SLUG-100B, SLUG-105 are onsite. Install and commission temporary bypass pumping facilities. Drain and clean the wet well and	Temporary bypass pumping is required.	2 – 5 days

ITEM NO./ DWG. NO.	ITEM DESCRIPTION	PROCESS UNITS OPERATING PRIOR TO SHUTDOWN	PROCESS UNITS OPERATING DURING SHUTDOWN	PROCESS UNITS OUT-OF-SERVICE DURING SHUTDOWN	IMPACT ON OTHER PROCESS UNITS	SUGGESTED PROCEDURE	CONSTRAINTS AND REMARKS	ESTIMATED DURATION OF SHUTDOWN
						upstream splitter structure as needed for demolishing the existing slide gates and installing new slide gates. Demolish existing slide gates. Install new slide gates.		
Phase 5	East Wet Well Pumps, Piping, and Epoxy Coating	N/A	Pumps P-101 and P-102 remain in service.	P-103 will be out of service due to lack of compressed air to operate pneumatic plug valve.	Number of available wastewater pumps will be two (2) instead of existing three (3). Flow capacity will be reduced. Compressed air connection to existing P-103 pneumatic plug valve will be severed and capped.	Verify new submersible pumps, associated VFDs are onsite. Install and commission temporary bypass pumping system. Drain and clean the east wet well. Lock out, disconnect and demolish Pump P-103. Clean and prepare concrete surfaces for epoxy coating. Apply epoxy coating and allow to properly cure. Install west wet well pumps, piping and VFDs. Once the piping is installed, connect to the existing force main piping connections. Install new pumps P-103 and P-104 and VFDs and place into service.	Temporary bypass pumping may be required.	4 – 8 days
Phase 6	West Wet Well Pumps, Piping and Epoxy Coating	N/A	Pumps P-103 and P-104 remain in service.	Pumps P-101 and P-102 will be out of service.	Number of available wastewater pumps will be two (2) instead of existing four (4). Flow capacity will be reduced.	Verify new submersible pumps and associated VFDs are onsite. Install and commission temporary bypass pumping system. Drain and clean the west wet well. Lockout, disconnect and demolish Pumps P-101 and P-102 from service.	West wet well pumps and piping demo must occur after existing west wet well header is depressurized and drained. Temporary bypass pumping may be required.	4 – 8 days

ITEM NO./ DWG. NO.	ITEM DESCRIPTION	PROCESS UNITS OPERATING PRIOR TO SHUTDOWN	PROCESS UNITS OPERATING DURING SHUTDOWN	PROCESS UNITS OUT-OF-SERVICE DURING SHUTDOWN	IMPACT ON OTHER PROCESS UNITS	SUGGESTED PROCEDURE	CONSTRAINTS AND REMARKS	ESTIMATED DURATION OF SHUTDOWN
						Contractor shall demo east wet well pumps and piping. Clean and prepare concrete surfaces for epoxy coating. Apply epoxy coating and allow to properly cure. Install replacement east wet well pumps, piping and VFDs. Once the piping and pumps are installed, they shall be reconnected to the existing piping. Place new pumps P-101 and P-102 to service.		
Phase 7	South Force Main Temporary Piping Connection Demolition	N/A	Pumps P-101, P-102, P-103, and P-104 will convey wastewater flow	None	N/A	Contractor shall demo the south force main temporary piping connection	Temporary bypass pumping may be required.	1 – 2 days
Phase 8	North Force Main Temporary Piping Connection Demolition	N/A	Pumps P-101, P-102, P-103, and P-104 will convey wastewater flow	None	N/A	Contractor shall demo the north force main temporary piping connection	Temporary bypass pumping may be required.	1 – 2 days

SECTION 01271

MEASUREMENT AND PAYMENT

PART 1 - GENERAL

1.1 DESCRIPTION

A. The items listed below, beginning with Article 1.4, refer to and are the same pay items listed in the Bid Form. They constitute all of the pay items for the completion of the Work. No direct or separate payment shall be made for providing miscellaneous temporary or accessory works, plant services, CONTRACTOR'S or ENGINEER'S field offices, layout surveys, job signs, sanitary requirements, testing, safety devices, approval and Record Drawings, water supplies, power, traffic maintenance, removal of waste, watchmen, bonds, insurance, permits, testing, quality control, and oversight, or all other requirements of the General Conditions, Supplementary Conditions, and the Contract Requirements. Compensation for all such services, items and materials shall be included in the prices stipulated for the lump sum and unit price pay items listed herein.

B. Each lump sum and unit bid price shall be deemed to include an amount considered by CONTRACTOR to be adequate to cover CONTRACTOR'S overhead and profit for each separately identified item.

1.2 ENGINEER'S ESTIMATE OF QUANTITIES

A. ENGINEER'S estimated quantities for unit price pay items, as listed in the Bid Form, are approximate only and are included solely for the purpose of comparison of Bids. OWNER does not expressly or by implication agree that the nature of the materials encountered below the surface of the ground, or the actual quantities of material encountered or required shall correspond therewith and reserves the right to increase or decrease any quantity or to eliminate any quantity as OWNER may deem necessary. Not entitled to any adjustment in a unit bid price as a result of any change in an estimated quantity and agrees to accept the aforesaid unit bid prices as complete and total compensation for any additions or deductions caused by changes or alterations in the Work directed by OWNER.

1.3 RELATED PROVISIONS

A. Payments to CONTRACTOR: Refer to General Conditions and Agreement.

B. Changes in Contract Price: Refer to General Conditions.
Schedule of Values: Refer to Section 01291, Schedule of Values.

C. Pay Application: Refer to Section 01331, Reference Forms.

1.4 GENERAL

A. Bid Item 1 – Mobilization, Demobilization, and Temporary Facilities:

1. Definition: Includes mobilization, demobilization, and all temporary facilities sitework prior to construction, and temporary facilities pertaining to water, electricity and lighting, telephone, heat, weather protection and ventilation, fire protection, sanitary and first aid facilities. This includes making ALL arrangements with utility service companies for temporary services.
2. Measurement and Payment: Payments shall be based on lump sum basis for mobilization, demobilization, and temporary facilities based on percent complete.

B. Bid item 2 – Furnish and Install 1" Non-Potable Water Piping (NPW):

1. Definitions: Provide all labor, materials, equipment, and other incidentals needed for the installation of all 1" NPW lines and other appurtenances. CONTRACTOR to perform all excavating, backfilling, grading, and disposing of earth materials and testing of all drain lines, fittings, and specials. CONTRACTOR shall perform all work in accordance with the drawings and specifications, see design drawings for approximate placement, specification 15051 for buried pipe installation and specification 15052 for exposed piping installation. CONTRACTOR shall provide record drawings, administration oversight, quality control, startup and testing along with all required permits, including environmental permits as required by authorities having jurisdiction, other overhead and incidental costs pertaining and associated with the installation of 1" NPW piping.
2. Measurement and Payment: Payment shall be made based on linear foot of NPW pipe installed as required in the description above and accepted by the OWNER and ENGINEER. Measurement of the actual quantities of materials and labor will be made by the CONTRACTOR and verified by the ENGINEER.

C. Bid item 3 – Furnish and Install 1" Drain Piping:

1. Definitions: Provide all labor, materials, equipment, and other incidentals needed for the installation of all 1" drain piping and other appurtenances. CONTRACTOR to perform all excavating, backfilling, grading, and disposing of earth materials and testing of all drain lines, fittings, and specials. CONTRACTOR shall perform all work in accordance with the drawings and specifications, see design drawings for approximate placement, specification 15051 for buried pipe installation and specification 15052 for exposed piping installation. CONTRACTOR shall provide record drawings, administration oversight, quality control, startup and testing along with all required permits, including environmental permits as required by authorities having jurisdiction, other overhead and incidental costs pertaining and associated with the installation of 1" drain piping.
2. Measurement and Payment: Payment shall be made based on linear foot of drain pipe installed as required in the description above and accepted by the

OWNER and ENGINEER. Measurement of the actual quantities of materials and labor will be made by the CONTRACTOR and verified by the ENGINEER.

D. Bid Item 4 – Furnish and Install 4" Drain Piping:

1. Definition: Provide all labor, materials, equipment, and other incidentals needed to install all 4" drain piping including pee traps and other appurtenances. CONTRACTOR to perform all excavating, backfilling, and grading per specification 15051. Piping includes installing and testing all drain lines, fittings, bends and specials. CONTRACTOR shall perform all work in accordance with the drawings and specifications and see design drawings for approximate placement. CONTRACTOR shall provide record drawings, administration oversight, quality control, startup and testing along with all required permits, including environmental permits as required by authorities having jurisdiction, other overhead and incidental costs pertaining and associated with the installation of 4" drain piping.
2. Measurement and Payment: Payments shall be based on linear foot of pipe installed as required in the description above and accepted by OWNER and ENGINEER. Measurement of the actual quantities of materials and labor will be made by the CONTRACTOR and verified by the ENGINEER.

E. Bid item 5 - Furnish and Install 2" Drain Piping:

1. Definition: Provide all labor, materials, equipment, and incidentals needed to install all new 2" drain lines and other appurtenances. CONTRACTOR to perform all excavating, backfilling, grading, and disposing of earth materials and testing of all drain lines, fittings, and specials. CONTRACTOR shall perform all work in accordance with the drawings and specifications, see design drawings for approximate placement, specification 15051 for buried pipe installation and specification 15052 for exposed piping installation. CONTRACTOR shall provide record drawings, administration oversight, quality control, startup and testing along with all required permits, including environmental permits as required by authorities having jurisdiction, other overhead and incidental costs pertaining and associated with the installation of 2" drain piping.
2. Measurement and Payments: Payment shall be made based on linear foot of drain line installed as required in the description above and accepted by the OWNER and ENGINEER. Measurement of the actual quantities of materials and labor will be made by the CONTRACTOR and verified by the ENGINEER.

F. Bid item 6 - Furnish and Install 2" Stainless Drain Piping:

1. Definition: Provide all labor, materials, equipment, and incidentals needed to install all new 2" stainless drain lines and other appurtenances. CONTRACTOR to perform all excavating, backfilling, grading, and disposing

of earth materials and testing of all drain lines, fittings, and specials. CONTRACTOR shall perform all work in accordance with the drawings and specifications, see design drawings for approximate placement, specification 15051 for buried pipe installation and specification 15052 for exposed piping installation. CONTRACTOR shall provide record drawings, administration oversight, quality control, startup and testing along with all required permits, including environmental permits as required by authorities having jurisdiction, other overhead and incidental costs pertaining and associated with the installation of 2" stainless drain piping.

2. Measurement and Payments: Payment shall be made based on linear foot of drain line installed as required in the description above and accepted by the OWNER and ENGINEER. Measurement of the actual quantities of materials and labor will be made by the CONTRACTOR and verified by the ENGINEER.

G. Bid Item 7 – Furnish and Install 2" PW:

1. Definition: Provide all labor, materials, equipment, and incidentals needed to install all potable water lines, and other appurtenances. CONTRACTOR to perform all excavating, backfilling, grading, and disposing of earth materials and to furnish, install and test all water lines, fittings, and specials. CONTRACTOR shall perform all work in accordance with the drawings and specifications, see design drawings for approximate placement, specification 15051 for buried pipe installation and specification 15052 for exposed piping installation. CONTRACTOR shall provide record drawings, administration oversight, quality control, startup and testing along with all required permits, including environmental permits as required by authorities having jurisdiction, other overhead and incidental costs pertaining and associated with the installation of 2" PW piping.
2. Measurement and Payment: Payment shall be made based on linear foot of 2" PW pipe installed as required by the description above and accepted by the OWNER and ENGINEER. Measurement of the actual quantities of materials and labor will be made by the CONTRACTOR and verified by the ENGINEER.

H. Bid Item 8 – Furnish and Install 2" NPW:

1. Definition: Provide all labor, materials, equipment, and incidentals needed to install all non-potable water lines, and other appurtenances. CONTRACTOR to perform all excavating, backfilling, grading, and disposing of earth materials and to furnish, install and test all drain lines, fittings, and specials. CONTRACTOR shall perform all work in accordance with the drawings and specifications, see design drawings for approximate placement, specification 15051 for buried pipe installation and specification 15052 for exposed piping installation. CONTRACTOR shall provide record drawings, administration oversight, quality control, startup and testing along with all required permits, including environmental permits as required by authorities having jurisdiction,

other overhead and incidental costs pertaining and associated with the installation of 2" NPW piping.

2. Measurement and Payment: Payment shall be made based on linear foot of 2" NPW pipe installed as required by the description above and accepted by the OWNER and ENGINEER. Measurement of the actual quantities of materials and labor will be made by the CONTRACTOR and verified by the ENGINEER.

I. Bid Item 9 – Furnish and Install New Reinforced Concrete:

1. Definition: Provide all labor, materials, equipment, other appurtenances, and incidentals needed to install all new reinforced concrete that is not concrete paving, concrete collar, or pipe supports as indicated on the Drawings and required per specification 03200. CONTRACTOR to perform all excavating, backfilling, grading, and disposing of earth materials. This work shall include but not limited to, all required formwork, fabrication and placement of reinforcement including but not limited to bars, ties, and supports, and welded wire fabric for concrete, and encasements. ALL work pertaining to excavation, subgrade preparation, backfill, and labor shall be completed by the CONTRACTOR at no additional cost. CONTRACTOR shall provide record drawings, administration oversight, quality control, startup and testing along with all required permits, including environmental permits as required by authorities having jurisdiction, other overhead and incidental costs pertaining and associated with the installation of new reinforced concrete.
2. Measurement and Payment: Payment shall be based on unit costs per cubic yard installed as required by the description above and accepted by the OWNER and ENGINEER. Measurement of the actual quantities of materials and labor will be made by the CONTRACTOR and verified by the ENGINEER.

J. Bid Item 10 – Furnish and Install New Asphalt Paving:

1. Definition: Provide all labor, material, equipment, and other incidentals needed to install all new asphalt paving complete and in place as shown on drawings and details. CONTRACTOR to perform all excavating, backfilling, grading, and disposing of earth materials. This work shall include but not limited to preparation of subgrade, pavement marking and testing as specified in specification 02742. ALL backfill and labor shall be completed by the CONTRACTOR at no additional cost. CONTRACTOR shall provide record drawings, administration oversight, quality control, startup and testing along with all required permits, including environmental permits as required by authorities having jurisdiction, other overhead and incidental costs pertaining and associated with the installation of new asphalt paving.
2. Measurement and Payment: Payment shall be made based on unit cost per square yard of asphalt installed as required in the description above and accepted by the OWNER and ENGINEER. Measurement of the actual

quantities of materials and labor will be made by the CONTRACTOR and verified by the ENGINEER.

K. Bid Item 11 – Furnish and Install New Concrete Paving:

1. Definition: Provide all labor, materials, equipment, and other incidentals needed to install all concrete paving, inspect and if needed replace ribbon curb, as indicated on the Drawings. CONTRACTOR to perform all excavating, backfilling, grading, and disposing of earth materials. This work shall include but not limited to preparation of subgrade, coarse graded base course, fine graded surface course, pavement marking and testing as specified. ALL backfill and labor shall be completed by the CONTRACTOR at no additional cost. CONTRACTOR shall provide record drawings, administration oversight, quality control, startup and testing along with all required permits, including environmental permits as required by authorities having jurisdiction, other overhead and incidental costs pertaining and associated with the installation of new concrete paving.
2. Measurement and Payment: Payment shall be based on unit costs per cubic yard installed as required by the description above and accepted by the OWNER and ENGINEER. Measurement of the actual quantities of materials and labor will be made by the CONTRACTOR and verified by the ENGINEER.

L. Bid Item 12 – Furnish and Install Electrical Building Trench Drain:

1. Definition: Provide all labor, materials, equipment, and other incidentals needed to install all new trench drain in front of the electrical building entrance complete and in place as required by the drawings and specifically per detail 6 Sheet 75. CONTRACTOR to perform all concrete cutting, demolition, excavating, backfilling, grading, and disposing of earth materials and to furnish, install and test the trench drain as required by the drawings. ALL backfill and labor shall be completed by the CONTRACTOR at no additional cost. CONTRACTOR shall provide record drawings, administration oversight, quality control, startup and testing along with all required permits, including environmental permits as required by authorities having jurisdiction; other overhead and incidental costs pertaining and associated with the installation of Electrical building trench drain.
2. Measurement and Payment: Payment shall be based on unit costs per each trench drain installed as required by the description above and accepted by the OWNER and ENGINEER. Measurement of the actual quantities of materials and labor will be made by the CONTRACTOR and verified by the ENGINEER.

M. Bid Item 13 – Remove and Replace Concrete Collars for Sewer Manholes:

1. Definition: Provide all labor, materials, equipment and appurtenances needed to remove and replace concrete collars for existing sewer manhole, adjust all ring and collar adjustment for existing fiberglass sewer manholes and other

existing sewer manholes, and other required incidentals as per MAG detail 422, after installation of new concrete and Asphalt pavement, as required per site plan on Sheet 17 of the drawings. CONTRACTOR shall provide record drawings, administration oversight, quality control, startup and testing along with all required permits, including environmental permits as required by authorities having jurisdiction, other overhead and incidental costs pertaining and associated with the adjustment of sewer manholes.

2. Measurement and Payment: Payments shall be made based on unit cost per each manhole collar adjustment as required by the description above and accepted by the OWNER and ENGINEER. Measurement of the actual quantities of materials and labor will be made by the CONTRACTOR and verified by the ENGINEER.

N. Bid Item 14 – Remove and Replace Concrete Collars for Electrical Manholes and Pull Boxes:

1. Definition: Provide all labor, materials, equipment, and appurtenances needed to adjust or remove and replace all concrete collars for existing electrical manholes or pull boxes and other required incidentals as per MAG detail 422 and specification 16138, after installation of new concrete and Asphalt pavement, as required per site plan on Sheet 17 of the drawings. CONTRACTOR shall provide record drawings, administration oversight, quality control, startup and testing along with all required permits, including environmental permits as required by authorities having jurisdiction; other overhead and incidental costs pertaining and associated with the adjustments for each electrical manhole and pull boxes.
2. Measurement and Payment: Payments shall be made based on unit cost per each manhole adjustment as required by the description above and accepted by the OWNER and ENGINEER. Measurement of the actual quantities of materials and labor will be made by the CONTRACTOR and verified by the ENGINEER.

O. Bid Item 15 – Furnish and Install Removable Bollards:

1. Definition: Provide all labor, material, equipment, and incidentals needed to install new removable bollards and other appurtenances as per Sheet 17 of the drawings and MAG detail 140. CONTRACTOR to ensure complete and operational installation per specifications and drawings. CONTRACTOR to perform all excavating, backfilling, grading, and disposing of earth materials. CONTRACTOR shall provide record drawings, administration oversight, quality control, startup and testing along with all required permits, including environmental permits as required by authorities having jurisdiction, other overhead and incidental costs pertaining and associated with the removal of existing bollards, installation of new removable bollards and other incidentals.
2. Measurement and Payment: Payments shall be made based on unit costs basis for each bollard installed as required by the description above and accepted by the OWNER and ENGINEER. Measurement of the actual quantities of

materials and labor will be made by the CONTRACTOR and verified by the ENGINEER.

P. Bid Item 16 – Demolition of Existing Lift Station Piping, Odor Control Facilities and Electrical Facilities:

1. Definition: Provide all labor, equipment, disposal, and other incidentals required for the demolition of existing electrical facilities, lift station piping and accessories, odor control facilities, and other site features as shown on the drawings except for light poles. Demolition and removals shall conform to the requirements of section 02220 Demolitions. All materials and equipment removed from the site, shall become the property of CONTRACTOR, except for those which OWNER has identified and marked for their use per drawings or identified by the OWNER at the preconstruction meeting. CONTRACTOR shall provide record drawings, administration oversight, quality control, all required permits, including environmental permits as required by authorities having jurisdiction, other overhead and incidental costs pertaining and associated with the demolition.
2. Measurement and Payment: Payments shall be based on lump sum basis for demolition and disposal as required in the description above. Payments will be made based on percent complete of each major site area identified above, percentages shall be agreed to by the OWNER and ENGINEER. Measurement of the percent complete shall be made by the CONTRACTOR and verified by the ENGINEER.

Q. Bid Item 17 – Remove and Dispose of Existing Light Poles:

1. Definition: Provide all labor, materials, equipment, and other incidentals needed for removal and disposal of existing light poles, and other appurtenances. Demolition and removals shall conform to the requirements of section 02220 Demolitions. All materials and equipment removed from existing work, shall become the property of CONTRACTOR, except for those which OWNER has identified and marked for their use per drawings or identified by the OWNER at the preconstruction meeting. CONTRACTOR shall provide record drawings, administration oversight, quality control, startup and testing along with all required permits, including environmental permits as required by authorities having jurisdiction, other overhead and incidental costs pertaining and associated with the removal and disposal of electrical light poles.
2. Measurement and Payment: Payments shall be based off a unit price per each light pole removed as required by the description above and accepted by the OWNER and ENGINEER. Measurement of the actual quantities of light poles removed will be made by the CONTRACTOR and verified by the ENGINEER.

R. Bid Item 18 – Provide Temporary Bypass Pumping:

1. Definition: Provide all labor, materials, pumps, piping, access points, repair or replacement of infrastructure removed or damaged by creating access points, and supervision required to temporarily bypass flow around the work in accordance with the specified needs of the rehabilitation method being utilized and dewater the wet well in preparation for cleaning and rehabilitation per specification 02145 and replacement of piping, appurtenances, electrical items, and other work required by the contract documents. CONTRACTOR to provide the design of the bypass arrangement and describe the means and methods of accomplishing the bypass and submit to the OWNER and ENGINEER to determine conformance to project objectives. CONTRACTOR shall provide MOPOs, record drawings, administration oversight, quality control, startup and testing along with all required permits, including environmental permits as required by authorities having jurisdiction, other overhead and incidental costs pertaining and associated with the installation of temporary bypass pumping.
2. Measurement and Payment: Payments shall be based off a lump sum basis for temporary bypass pumping as required by the description above based on percent complete. Measurement of the percent complete shall be made by the CONTRACTOR and verified by the ENGINEER.

S. Bid Item 19 – Install of Pre-Purchased Submersible Pumps and Accessories:

1. Definition: Provide all labor and incidentals and other appurtenance needed for installation of pre-purchased submersible pumps. CONTRACTOR shall conform to all requirements indicated in specifications 016000, 01620, and 01651, CONTRACTOR shall verify pumps are operational and coordinate any issues with the OWNER. Pump start up services are included in the pre-purchased from the vendor, CONTRACTOR shall coordinate pump start-up and shall coordinate all issues with the OWNER. Pump warranty, O&M manuals and training are included in the pre-purchase, CONTRACTOR shall coordinate any issues with the pump supplier and the OWNER. Refer to approved pre-purchase submittals for additional information and clarifications. CONTRACTOR shall be responsible to coordinate the means and methods of shipment, delivery, and offloading from the location that the OWNER is storing the pre-purchased pumps and shall provide onsite storage, installation, and other commissioning with above requirements and the specifications of the manufacture of all pre-purchased equipment. CONTRACTOR shall provide record drawings, administration oversight, quality control, startup and testing along with all required permits, including environmental permits as required by authorities having jurisdiction, other overhead and incidental costs pertaining and associated with the installation pre-purchased submersible pumps.
2. Measurement and Payment: Payments shall be based on per unit cost basis of each installed pre-purchased submersible pump installed as required by the description above and accepted by the OWNER and ENGINEER.

Measurement of the materials and labor will be made by the CONTRACTOR and verified by the ENGINEER.

T. Bid Item 20 – Install Pre-purchased 24" Eccentric Plug Valves:

1. Definition: Provide all labor and incidentals and other appurtenance needed for installation of all pre-purchased 24" eccentric plug valves. Valve warranty, O&M manuals, and training were included in the pre-purchase, CONTRACTOR shall coordinate any issues with the valve supplier and the OWNER. Refer to approved pre-purchase submittals for additional information and clarifications. Valve set up and testing shall be done by qualified representatives from valve manufacture. CONTRACTOR shall provide record drawings, administration oversight, quality control, startup and testing along with all required permits, including environmental permits as required by authorities having jurisdiction, other overhead and incidental costs pertaining and associated with the installation 24" Pre-Purchased Eccentric Plug Valves.
2. Measurement and Payment: Payment shall be based on unit cost basis of each installed pre-purchased 24" plug valve per above description and accepted by the OWNER and ENGINEER. Measurement of the materials and labor will be made by the CONTRACTOR and verified by the ENGINEER.

U. Bid Item 21 – Install Pre-purchased 16" Eccentric Plug Valves:

1. Definition: Provide all labor, incidentals, and other appurtenance needed for installation of pre-purchased 16" eccentric Plug valves. CONTRACTOR shall conform to all requirements indicated in specifications 016000, 01620, and 01651, CONTRACTOR shall verify valves are operational and coordinate any issues with the OWNER. Valve warranty, O&M manuals, and training are included in the pre-purchase, CONTRACTOR shall coordinate any issues with the valve supplier and the OWNER. Refer to approved pre-purchase submittals for additional information and clarifications. Valve set up and testing shall be done by qualified representatives form valve manufacture. CONTRACTOR shall provide record drawings, administration oversight, quality control, startup and testing along with all required permits, including environmental permits as required by authorities having jurisdiction; other overhead and incidental costs pertaining and associated with the installation pre-purchased 16" eccentric plug valves.
2. Measurement and Payment: Payment shall be based on unit cost basis of each installed pre-purchased 16" plug valve per above description and accepted by the OWNER and ENGINEER. Measurement of the materials and labor will be made by the CONTRACTOR and verified by the ENGINEER.

V. Bid Item 22 – Install Pre-Purchased 16" Anti-Salm Check Valves:

1. Definition: Provide all labor and incidentals and other appurtenance needed for installation of pre-purchased 16" Anti-Slam check valves. CONTRACTOR shall conform to all requirements indicated in specifications 016000, 01620,

and 01651, CONTRACTOR shall verify valves are operational and coordinate any issues with the OWNER. Valve warranty, O&M manuals, and training are included in the pre-purchase, CONTRACTOR shall coordinate any issues with the valve supplier and the OWNER. Refer to approved pre-purchase submittals for additional information and clarifications. Valve set up and testing shall be done by qualified representatives form valve manufacture. CONTRACTOR shall provide record drawings, administration oversight, quality control, startup and testing along with all required permits, including environmental permits as required by authorities having jurisdiction, other overhead and incidental costs pertaining and associated with the installation pre-purchased 16" anti-slam check valves.

2. Measurement and Payment: Payment shall be based on unit cost basis of each installed pre-purchased check valve per above description and accepted by the OWNER and ENGINEER. Measurement of the materials and labor will be made by the CONTRACTOR and verified by the ENGINEER.

W. Bid Item 23 – Furnish and Install New Pipe Supports:

1. Definition: Provide all labor, materials, concrete, all required formwork, fabrication and placement of reinforcement including but not limited to bars, ties, supports, equipment, and incidentals required to furnish and install all new pipe supports and appurtenances as shown on sheet 79 detail 2 of the drawings. ALL work pertaining to excavation, subgrade preparation, backfill, and labor shall be completed by the CONTRACTOR at no additional cost. CONTRACTOR shall provide record drawings, administration oversight, quality control, and testing, along with all required permits, including environmental permits as required by authorities having jurisdiction, other overhead and incidental costs pertaining and associated with the installation new pipe supports.
2. Measurement and Payment: Payment shall be based on unit costs for each new pipe supports installed as described above and accepted by the OWNER and ENGINEER. Measurement of the materials and labor will be made by the CONTRACTOR and verified by the ENGINEER.

X. Bid Item 24 –Install Pre-Purchased 8" Plug Valves:

1. Definition: Provide all labor and incidentals and other appurtenance needed for installation of pre-purchased 8" plug valves as required by the drawings and specifications. CONTRACTOR shall conform to all requirements indicated in specifications 016000, 01620, and 01651, CONTRACTOR shall verify valves are operational and coordinate any issues with the OWNER. Valve warranty, O&M manuals, and training are included in the pre-purchase, CONTRACTOR shall coordinate any issues with the valve supplier and the OWNER. Refer to approved pre-purchase submittals for additional information and clarifications. Valve set up and testing shall be done by qualified representatives form valve manufacture. CONTRACTOR shall provide record drawings, administration oversight, quality control, startup and

testing along with all required permits, including environmental permits as required by authorities having jurisdiction; other overhead and incidental costs pertaining and associated with the installation pre-purchased 8" plug valves.

2. Measurement and Payment: Payment shall be based on unit cost basis per each 8" plug valve installed per the description above and accepted by the OWNER and ENGINEER. Measurement of the materials and labor will be made by the CONTRACTOR and verified by the ENGINEER.

Y. Bid Item 25 –Install Pre-Purchased 8" Surge Relief Valves:

1. Definition: Provide all labor and incidentals and other appurtenance needed for installation of pre-purchased 8" Surge Relief valves as required by the drawings and specifications. CONTRACTOR shall conform to all requirements indicated in specifications 016000, 01620, and 01651, CONTRACTOR shall verify valves are operational and coordinate any issues with the OWNER. Valve warranty, O&M manuals, and training were included in the pre-purchase, CONTRACTOR shall coordinate any issues with the valve supplier and the OWNER. Refer to approved pre-purchase submittals for additional information and clarifications. Valve set up and testing shall be done by qualified representatives from valve manufacturer. CONTRACTOR shall provide record drawings, administration oversight, quality control, startup and testing along with all required permits, including environmental permits as required by authorities having jurisdiction, other overhead and incidental costs pertaining and associated with the installation pre-purchased 8" surge relief valves.
2. Measurement and Payment: Payment shall be based on unit cost per each pre-purchased 8" surge relief valve installed and accepted by the OWNER and ENGINEER. Measurement of the materials and labor will be made by the CONTRACTOR and verified by the ENGINEER.

Z. Bid Item 26 – Install Pre-Purchased 6" Plug Valve:

1. Definition: Provide all labor and incidentals and other appurtenance needed for installation of pre-purchased 6" plug valves as required by the drawings and specifications. CONTRACTOR shall conform to all requirements indicated in specifications 016000, 01620, and 01651, CONTRACTOR shall verify valves are operational and coordinate any issues with the OWNER. Valve warranty, O&M manuals, and training were included in the pre-purchase, CONTRACTOR shall coordinate any issues with the valve supplier and the OWNER. Refer to approved pre-purchase submittals for additional information and clarifications. Valve set up and testing shall be done by qualified representatives from valve manufacturer. CONTRACTOR shall provide record drawings, administration oversight, quality control, startup and testing along with all required permits, including environmental permits as required by authorities having jurisdiction, other overhead and incidental costs pertaining and associated with the installation pre-purchased 6" plug valves.

2. Measurement and Payment: Payment shall be based on unit cost per each 6" valve installed and accepted by the OWNER and ENGINEER. Measurement of the materials and labor will be made by the CONTRACTOR and verified by the ENGINEER.

AA. Bid Item 27 –Install Pre-Purchased 6" Combination Air Release Valves:

1. Definition: Provide all labor and incidentals and other appurtenance needed for installation of pre-purchased 6" combination air release valves as required by the drawings and specifications. CONTRACTOR shall conform to all requirements indicated in specifications 016000, 01620, and 01651, CONTRACTOR shall verify valves are operational and coordinate any issues with the OWNER. Valve warranty, O&M manuals, and training were included in the pre-purchase, CONTRACTOR shall coordinate any issues with the valve supplier and the OWNER. Refer to approved pre-purchase submittals for additional information and clarifications. Valve set up and testing shall be done by qualified representatives from valve manufacturer. CONTRACTOR shall provide record drawings, administration oversight, quality control, startup and testing along with all required permits, including environmental permits as required by authorities having jurisdiction, other overhead and incidental costs pertaining and associated with the installation pre-purchased 6" combination air release valves.
2. Measurement and Payment: Payment shall be based on unit cost per each 6" combination air release valve installed and accepted by the OWNER and ENGINEER. Measurement of the materials and labor will be made by the CONTRACTOR and verified by the ENGINEER.

AB. Bid Item 28 – Furnish and Install 3" Air Vacuum Valves:

1. Definition: Provide all labor, materials and equipment and incidentals required to furnish and install all 3" Air Vacuum valves and other appurtenances, complete and in place as required by the drawings and specifications, specifically shown on the drawing detail 5 on sheet 80. CONTRACTOR shall ensure valves are operational. CONTRACTOR shall provide record drawings, administration oversight, quality control, and testing, along with all required permits, including environmental permits as required by authorities having jurisdiction, other overhead and incidental costs pertaining and associated with the installation of all 3" air vacuum valves.
2. Measurement and Payment: Payment shall be based on a unit cost per each 3" air vacuum valves installed per the description above and accepted by the OWNER and ENGINEER. Measurement of the materials and labor will be made by the CONTRACTOR and verified by the ENGINEER.

AC. Bid Item 29 – Furnish and Install 3" Ball Valves:

1. Definition: Provide all labor, materials, equipment, and incidentals required to furnish and install all 3" ball valves not covered above and other appurtenances, complete and in place as required by the drawings and

specifications and specifically shown on the drawing detail 5 sheet 80 and as described in section 15115 Ball Valves, Operators and Appurtenances. CONTRACTOR shall ensure valves are operational. CONTRACTOR shall provide record drawings, administration oversight, quality control, and testing, along with all required permits, including environmental permits as required by authorities having jurisdiction, other overhead and incidental costs pertaining and associated with the installation of all 3" ball valves.

2. Measurement and Payment: Payment shall be based on a unit cost basis for each 3" ball valves installed per the description above and accepted by the OWNER and ENGINEER. Measurement of the materials and labor will be made by the CONTRACTOR and verified by the ENGINEER.

AD. Bid Item 30 – Furnish and Install 2" Ball Valves:

1. Definition: Provide all labor, materials, equipment, and incidentals required to furnish and install all 2" Ball valves not covered above and other appurtenances, complete and in place as required by the drawings and specifications and shown on the drawing detail 5 sheet 80 and as described in section 15115 Ball Valves, Operators and Appurtenances. CONTRACTOR shall ensure valves are operational. CONTRACTOR to perform all excavating, backfilling, and disposing of earth materials. CONTRACTOR shall provide record drawings, administration oversight, quality control, and testing, along with all required permits, including environmental permits as required by authorities having jurisdiction, other overhead and incidental costs pertaining and associated with the installation of all 2" ball valves.
2. Measurement and Payment: Payment shall be based on a unit cost basis for each 2" ball valves installed per the description above and accepted by the OWNER and ENGINEER. Measurement of the materials and labor will be made by the CONTRACTOR and verified by the ENGINEER.

AE. Bid item 31 – Furnish and Install 1" Solenoid Valve:

1. Definition: Provide all labor, materials and equipment and incidentals required to furnish and install all 1" solenoid valves and other appurtenances as required by the drawings and the specifications; CONTRACTOR shall ensure valves are operational. CONTRACTOR to perform all excavating, backfilling, and disposing of earth materials. CONTRACTOR shall provide record drawings, administration oversight, quality control, and testing, along with all required permits, including environmental permits as required by authorities having jurisdiction, other overhead and incidental costs pertaining and associated with the installation of all 1" solenoid valves.
2. Measurement and Payment: Payment shall be based on unit cost per each 1" isolation valves installed per the description above and accepted by the OWNER and ENGINEER. Measurement of the materials and labor will be made by the CONTRACTOR and verified by the ENGINEER.

AF. Bid item 32 – Furnish and Install 1" Isolation Valve:

1. Definition: Provide all labor, materials and equipment and incidentals required to furnish and install all 1" isolation valves and other appurtenances as required by the drawings and specifications; CONTRACTOR shall ensure valves are operational. CONTRACTOR to perform all excavating, backfilling, and disposing of earth materials. CONTRACTOR shall provide record drawings, administration oversight, quality control, and testing, along with all required permits, including environmental permits as required by authorities having jurisdiction, other overhead and incidental costs pertaining and associated with the installation of all 1" isolation valves.
2. Measurement and Payment: Payment shall be based on unit cost per each 1" isolation valves installed per the description above and accepted by the OWNER and ENGINEER. Measurement of the materials and labor will be made by the CONTRACTOR and verified by the ENGINEER.

AG. Bid Item 33 – Furnish and install New Magnetic Flow Meter:

1. Definition: Provide all labor, materials, equipment, and incidentals required to furnish and install new magnetic flow meters and appurtenances, complete and operational, as required by the drawings and specifications. CONTRACTOR to ensure that flow meter is operational. CONTRACTOR shall provide record drawings, administration oversight, quality control, and testing, along with all required permits, including environmental permits as required by authorities having jurisdiction, other overhead and incidental costs pertaining and associated with the installation of all magnetic flow meter.
2. Measurement and Payment: Payment shall be based on unit costs per each magnetic flow meter installed per the description above and accepted by the OWNER and ENGINEER. Measurement of the materials and labor will be made by the CONTRACTOR and verified by the ENGINEER.

AH. Bid Item 34 – Furnish and Install Yard Piping and all Appurtenances not Listed Above:

1. Definition: Provide all labor, materials, and equipment and incidentals required to furnish and install all large diameter yard piping, fittings which are not pre-purchased, various sized valves and appurtenances complete and operational as required by the drawings and specifications. CONTRACTOR shall refer to design drawings for approximate placement, specification 15051 for buried pipe installation and specification 15052 for exposed piping installation. CONTRACTOR to perform all excavating, backfilling, filling, grading and disposing of earth materials and to furnish, install and test all yard piping, fittings, and specials. CONTRACTOR shall provide record drawings, administration oversight, quality control, and testing, along with all required permits, including environmental permits as required by authorities having jurisdiction, other overhead and incidental costs pertaining and associated with the installation of all magnetic flow meter.
2. Measurement and Payment: Payments shall be based on lump sum basis for yard piping installed based on percent complete per the description above and

accepted by the OWNER and ENGINEER. Measurement of the percent complete will be made by the CONTRACTOR and verified by the ENGINEER.

AI. Bid Item 35 – Furnish and Install New Safety Tie Offs:

1. Definition: Provide all labor, materials, and other incidentals required to install new safety tie offs around wet well openings as required by the drawings and specifications. CONTRACTOR shall ensure tie offs are installed per manufacturer's specifications, including 3rd party testing, verification, and certification and providing all associated documents for approved use. CONTRACTOR shall provide record drawings, administration oversight, quality control, and testing, along with all required permits, including environmental permits as required by authorities having jurisdiction, other overhead and incidental costs pertaining and associated with the installation of all safety tie offs.
2. Measurement and Payment: Payment shall be made based on unit cost per each tie off system installed per the description above and accepted by the OWNER and ENGINEER. Measurement of the materials and labor will be made by the CONTRACTOR and verified by the ENGINEER.

AJ. Bid Item 36 – Furnish and Install New Removable Handrail for Splitter Box Hatches:

1. Definition: Provide all labor, materials, equipment, and incidentals needed to furnish and install all new removable handrails and other appurtenances complete and operational as required by the drawings and specifications and specifically shown on drawings on sheet 50, detail 3. CONTRACTOR shall provide record drawings, administration oversight, quality control, and testing, along with all required permits, including environmental permits as required by authorities having jurisdiction, other overhead and incidental costs pertaining and associated with the installation of all removable handrails for splitter box hatches.
2. Measurement and Payment: Payment shall be based on unit cost per each hatch the removable handrail installed on per the description above and accepted by the OWNER and ENGINEER. Measurement of the materials and labor will be made by the CONTRACTOR and verified by the ENGINEER.

AK. Bid Item 37 – Furnish and Install New Removable Handrail for Wet Well Hatches:

1. Definition: Provide all labor, materials, equipment, and incidentals needed to furnish and install all new removable handrails and other appurtenances complete and operational as required by the drawings and specifications and specifically shown on drawings on sheet 50, detail 3. CONTRACTOR shall provide record drawings, administration oversight, quality control, and testing, along with all required permits, including environmental permits as required by authorities having jurisdiction; other overhead and incidental costs

pertaining and associated with the installation of all removable handrails for wet well hatches. Measurement of the materials and labor will be made by the CONTRACTOR and verified by the ENGINEER.

2. Measurement and Payment: Payment shall be based on unit cost per each wet well the removable handrail installed on per the description above and accepted by the OWNER and ENGINEER. Measurement of the materials and labor will be made by the CONTRACTOR and verified by the ENGINEER.

AL. Bid Item 38 – Furnish and Install Biofilter Containment Area Handrail System:

1. Definition: Provide all labor, materials, equipment, connections to existing handrails, and incidentals needed to furnish and install all biofilter containment area handrail system and other appurtenances complete and operational as required by the drawings and specifications and specifically shown on drawings on sheet 58, detail 1. CONTRACTOR shall provide record drawings, administration oversight, quality control, and testing, along with all required permits, including environmental permits as required by authorities having jurisdiction, other overhead and incidental costs pertaining and associated with the installation of all biofilter containment area handrail system.
2. Measurement and Payment: Payment shall be based on unit cost per linear foot of biofilter containment area handrail system installed per the description above and accepted by the OWNER and ENGINEER. Measurement of the materials and labor will be made by the CONTRACTOR and verified by the ENGINEER.

AM. Bid Item 39 – Furnish and Install Miscellaneous Improvements for Electrical Building:

1. Definition: Provide all labor, materials, and equipment and other incidentals need for installation of sweep gaskets, threshold plates, resealing HVAC penetrations, reseal roof penetrations, repair gutters and other miscellaneous external improvements as shown on the drawings excluding trench drains. CONTRACTOR shall provide record drawings, administration oversight, quality control, and testing, along with all required permits, including environmental permits as required by authorities having jurisdiction, other overhead and incidental costs pertaining and associated with the installation of all electrical building improvement.
2. Measurement and Payment: Payment shall be based on lump sum basis for the electrical building miscellaneous improvements installed based on percent complete per the description above and accepted by the OWNER and ENGINEER. Measurement of the materials and labor will be made by the CONTRACTOR and verified by the ENGINEER.

AN. Bid Item 40 – Furnish and Install New Epoxy Coating for Wet Well and Splitter Structures:

1. Definition: Provide all labor, materials, and other incidentals as shown and specified and required to furnish, install and place into satisfactory service the epoxy lining corrosion system as required by the drawings, specifications, and requirements of the epoxy manufacturer and described in specification 09985 Novolac epoxy. Installation shall include surface preparation, cleaning, disposal of derelict material removed, and placement of coating system. CONTRACTOR shall provide record drawings, administration oversight, quality control, and testing, along with all required permits, including environmental permits as required by authorities having jurisdiction; other overhead and incidental costs pertaining and associated with the installation of all Novolac epoxy coating.
2. Measurement and Payment: Payment shall be based on unit cost per square foot of wet well coating system installed per the description above and accepted by the OWNER and ENGINEER. Measurement of the materials and labor will be made by the CONTRACTOR and verified by the ENGINEER.

AO. Bid Item 41 – Furnish and Install New Flow Control Gates:

1. Definition: Provide all labor, materials, equipment, and other incidentals as shown and specified and required to furnish, install and place into satisfactory service the flow control gates as required by the drawings and specifications. CONTRACTOR shall provide record drawings, administration oversight, quality control, and testing, along with all required permits, including environmental permits as required by authorities having jurisdiction; other overhead and incidental costs pertaining and associated with the installation of all flow control gates.
2. Measurement and Payment: Payment shall be based on unit cost per each flow control gate installed per the description above and accepted by the OWNER and ENGINEER. Measurement of the materials and labor will be made by the CONTRACTOR and verified by the ENGINEER.

AP. Bid Item 42 – Furnish and Install New Biofilter Odor Control Facilities:

1. Definition: Provide all labor, materials, equipment, and incidentals needed to install the biofilter odor control facilities as required by the drawings and specifications. CONTRACTOR shall ensure installation and operation of the following, biofilter control facilities, media, blower, utilities relocation, duct work, housekeeping pads per detail on sheet 76 of drawing, dampers, and horizontal grease filter. CONTRACTOR shall provide all excavation, subgrade preparation, and backfill as required by the drawings and specifications. CONTRACTOR shall provide record drawings, administration oversight, quality control, and testing, along with all required permits, including environmental permits as required by authorities having jurisdiction, other overhead and incidental costs pertaining and associated with the installation of new biofilter odor control facilities.
2. Measurement and Payment: Payment shall be made based on lump sum for installation of the biofilter odor control facilities as required by the description

above and shall be paid based on percent complete. Measurement of the percent complete will be made by the CONTRACTOR and verified by the ENGINEER.

AQ. Bid Item 43 – Install Pre-Purchased Variable Frequency Drives (VFDs):

1. Definition: Provide all labor and incidentals and other appurtenance needed for installation of pre-purchased VFDs. CONTRACTOR shall install VFDs as required by the drawings and specifications. CONTRACTOR shall ensure VFDs are operational prior to taking possession of the pre-purchased VFDs. VFD warranty, O&M manuals, and training are included in the pre-purchase, CONTRACTOR shall coordinate any issues with the VFD supplier and the OWNER. Refer to approved pre-purchase submittals for additional information and clarifications. CONTRACTOR shall provide record drawings, administration oversight, quality control, startup and testing along with all required permits, including environmental permits as required by authorities having jurisdiction, other overhead and incidental costs pertaining and associated with the installation pre-purchased VFDs.
2. Measurement and Payment: Payment shall be based on unit cost per each pre-purchased VFD installed per the description above and accepted by the OWNER and ENGINEER. Measurement of the materials and labor will be made by the CONTRACTOR and verified by the ENGINEER.

AR. Bid Item 44 – Furnish and Install Electrical Facilities:

1. Definition: Provide all labor, materials, equipment, and incidentals as required to complete the electrical work by the drawings and specifications. Including but not limited to all new electrical duct banks, motor control centers, conduit, wire, electrical panels, pull boxes, electrical appurtenances and accessories as described in drawings and section 16050. CONTRACTOR shall provide record drawings, administration oversight, quality control, startup and testing along with all required permits, including environmental permits as required by authorities having jurisdiction, other overhead and incidental costs pertaining and associated with the installation electrical facilities.
2. Measurement and Payment: Payments shall be made as a lump sum basis for all electrical items and other appurtenances as described above based on percent complete accepted by the OWNER and ENGINEER. Measurement of the percent complete will be made by the CONTRACTOR and verified by the ENGINEER.

AS. Bid Item 45 – Furnish and Install Instrumentation, Controls and Accessories:

1. Definition: Provide all labor, materials and equipment needed to furnish and install all instrumentation, control panels, programmable logic controllers, programming integration, conduit, wire, fire alarm system and appurtenances complete and operational as required by the drawings and specifications and specifically in specification 17001 Process control systems General requirements. CONTRACTOR shall provide record drawings, administration

oversight, quality control, startup and testing along with all required permits including environmental permits as required by authorities having jurisdiction, other overhead and incidental costs pertaining and associated with the installation instrumentation and controls.

2. Measurement and Payment: Payments shall be made as lump sum for installation of all instrumentation, controls, and other appurtenances as described above based on percent complete accepted by the OWNER and ENGINEER. Measurement of the percent complete will be made by the CONTRACTOR and verified by the ENGINEER.

AT. Bid Item 46 – Furnish and Install Protective Finishes:

1. Definition: Provide all labor, materials, equipment, and other incidentals needed to provide all proper finishes and apply paint systems to all applicable surfaces except the wet well including but not limited to yard piping, electrical facilities, removable bollards, new odor control facilities, yard hydrants, and other equipment that exposed to the elements as required by the drawings and specifications and specifically per specification 09900. This includes proper surface preparation and painting of all new and existing interior and exterior items and surfaces. CONTRACTOR shall provide record drawings, administration oversight, quality control, startup and testing along with all required permits including environmental permits as required by authorities having jurisdiction, other overhead and incidental costs pertaining and associated with the installation protective finishes.
2. Measurement and Payment: Payment shall be made as a lump sum for installation of protective finishes as required by the description above based on percent complete and approved by the OWNER and ENGINEER. Measurement of the percent complete will be made by the CONTRACTOR and verified by the ENGINEER.

AU. Bid Item 47 – All Other Work Not Previously Listed:

1. Definition: Includes all other work, labor, material, coordination, equipment, and incidentals not specifically listed in the aforementioned bid items but required by the Drawings and Specifications.
2. Measurement and Payment: Payment shall be made as a lump sum for all work not previously listed as required by the description above based on percent complete and approved by the OWNER and ENGINEER. Measurement of the percent complete will be made by the CONTRACTOR and verified by the ENGINEER.

AV. Bid Item 48 – Allowance for Unforeseen Conditions:

1. Definition: Allowance for unforeseen conditions for items and conditions that are requested and authorized in writing by the OWNER.
2. Measurement and Payment: Payments shall be made based on the terms agreed to in writing by the OWNER and CONTRCTOR for unforeseen conditions.

Measurement of the materials and labor will be made by the CONTRACTOR and verified by the ENGINEER.

AW. Bid Item 49 – Allowance for Stormwater Pollution Protection Permit (SWPPP):

1. Definition: Includes work associated with Stormwater Pollution Protection Permit that is required for the completion of the work. All temporary means required to prevent discharge of sediment to water courses from dewatering systems or erosion shall be included. All temporary means required to prevent discharge of sediment to water courses from dewatering systems or erosion are included. CONTRACTOR shall obtain the SWPPP from authorities having jurisdiction, including all coordination, development of plan, development of submittals, materials and labor to install and maintain pollution protection measures, all overhead, administration, and other incidental item required for the SWPPP.
2. Measurement and Payment: Payment shall be made as an allowance for the SWPPP as required by the description above based on percent complete and approved by the OWNER and ENGINEER. Measurement of the percent complete will be made by the CONTRACTOR and verified by the ENGINEER.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 01291

SCHEDULE OF VALUES

PART 1 - GENERAL

1.1 DESCRIPTION

A. The Preliminary Schedule of Values is an itemized list that establishes the value or cost of each major part of the Work and the division of Work between CONTRACTOR and subcontractors.

B. The Preliminary Schedule of Values shall include all items of Work in the Contract Documents.

C. The Schedule of Values is a detailed itemized list that establishes the value or cost of each detailed part of the Work. It and the Progress Schedule updates specified in Section 01321 – Progress Schedule CPM, shall be used as the basis for preparing progress payments. The Schedule of Values may be used as a basis for negotiations, concerning additional work or credits, which may arise during the construction. Quantities and unit prices shall be included in the schedule, when approved by or required by the ENGINEER.

D. The Preliminary Schedule of Values and Schedule of Values itemized list of Work, for each major part of the Work and division of Work shall be grouped under the following index areas:
   1. Mobilization, Demolition, and Temporary Facilities.
   2. Furnish and install 1" Non-Potable Water Piping (NPW).
   3. Furnish and Install 4" Drain Piping.
   4. Furnish and Install 2" Drain Piping.
   5. Furnish and install 2" PW.
   6. Furnish and install 2" NPW.
   7. Furnish and Install New Reinforced Concrete.
   8. Furnish and Install New Asphalt Paving.
   9. Furnish and Install New Concrete Paving.
   10. Furnish and Install Electrical Building Trench Drain.
   11. Remove and Replace Concrete Collars for Sewer Manholes.
   12. Remove and Replace Concrete Collars for Electrical Manholes and Pull Boxes.
   13. Furnish and Install Removable Bollards.
   14. Demolition of Existing Lift Station Piping, Odor Control Facilities and Electrical Facilities.
   15. Remove and Dispose of Existing Light Poles.
   16. Provide Temporary Bypass pumping.
   17. Install Pre-purchased Submersible Pumps and Accessories.
   18. Install Pre-Purchased 24" Eccentric Plug Valves.
   19. Install Pre-Purchased 16" Eccentric Plug Valves.

20. Install Pre-purchase 16" Anti-Slam Check valves.
21. Furnish and Install New Pipe Supports.
22. Install Pre-Purchased 8" Plug valves.
23. Install Pre-Purchased 8" Surge Release Valves.
24. Install Pre-Purchased 6" Plug Valves.
25. Install Pre-Purchased 6" Combination Air Release Valves.
26. Furnish and Install 3" Air Vacuum Valves.
27. Furnish and Install 3" Ball Valve.
28. Furnish and Install 2" Ball Valves.
29. Furnish and Install 1" Solenoid Valve.
30. Furnish and Install 1" Isolation Valve.
31. Furnish and Install New Magnetic flow meters.
32. Furnish and Install Yard piping and all Appurtenances not listed above.
33. Furnish and Install New safety tie offs.
34. Furnish and Install New Removable Handrail for Splitter Box Hatches.
35. Furnish and Install New Removable Handrail for Wet Well Hatches.
36. Furnish and Install Biofilter Containment area handrail system.
37. Furnish and Install Miscellaneous Improvements for Electrical Building.
38. Furnish and Install New Epoxy Coating for New Wet Well and Splitter Structures.
39. Furnish and Install New Flow Control Gates.
40. Furnish and Install New Biofilter Odor Control Facilities.
41. Install Pre-purchased Variable Frequency Drives (VFDs).
42. Furnish and Install Electricals Facilities.
43. Furnish and Install Instrumentation, Controls and Accessories.
44. Furnish and Install Protective Finishes.
45. All other Work Not Previously Listed.
46. Allowance for Unforeseen Conditions.
47. Allowance For Stormwater Pollution Protection Permit (SWPPP).

E. The Schedule of Values shall include an itemized list of Work for all Maintenance of Plant Operations (MOPO) Work as specified in Section 01143, Coordination with OWNER'S Operations. Itemized MOPO Work shall be included within applicable major Work area.

1.2 PREPARATION

A. The Preliminary Schedule of Values:
   1. Preliminary Schedule of Values shall show all Work under the index areas listed in Paragraph 1.1.D., above.
   2. Preliminary Schedule of Values shall show the division of Work between CONTRACTOR and subcontractors by two methods, one for each Section of the Specifications and also one for each structure.
   3. Preliminary Schedule of Values shall show breakdown of labor, materials equipment and other costs used in preparation of the Bid for CONTRACTOR and subcontractors.

4. Costs shall be in sufficient detail to indicate separate amounts for each Section of the Specifications and for each structure.
5. May include an item for bond, insurance, and temporary facilities.
6. Preliminary Schedule of Values shall be prepared on 8-1/2-inch by 11-inch white paper.
7. Use Table of Contents of the Specifications as basis for Preliminary Schedule of Values format and identify each item with number and title in the Table of Contents. Also, use each structure as basis for Schedule of Value format. List sub-items of major products or systems, as appropriate or when requested by ENGINEER.
8. When requested by ENGINEER, support values with data that will substantiate their correctness.
9. The sum of the individual values shown on the Preliminary Schedule of Values shall equal the total Contract Price.
10. Each item shall include a directly proportional amount of CONTRACTOR'S overhead and profit.

B. The Schedule of Values:
1. Schedule of Values shall show breakdown of quantities, labor, materials, equipment, and other costs used in preparation of the Bid for each item in the Schedule of Values.
2. Schedule of Values shall show all Work under the index areas listed in Paragraph 1.1.D., above.
3. Costs shall be prepared by two methods, one for each Section of the Specifications and one for each structure. They shall be in sufficient detail to indicate separate amounts for each Section of the Specifications and subsections therein and also separate amounts for each structure. Amounts shall be included for each type of Work specified, in a manner approved by the ENGINEER.
4. Include separate pay items for Mobilization and Demobilization, as specified in the Contract Documents.
5. Fifteen percent of the total cost of each item is allotted to the cost of Shop Drawing preparation, Operation and Maintenance Manuals, Testing and Training. This amount will be released upon approval, by the ENGINEER, three percent is apportioned to Testing and four percent each to the remaining items.
6. Schedule of Values shall be prepared on 8-1/2-inch by 11-inch white paper.
7. Use Table of Contents of the Specifications and the form included with Section 01330, Submittals, as basis for Schedule of Values format and identify each item with number and title in the Table of Contents. Also, use each structure as basis for schedule format. List sub-items of major products or systems, as appropriate or when requested by ENGINEER.
8. When requested by ENGINEER, support values with data that will substantiate their correctness.
9. The sum of the individual values shown on the Schedule of Values shall equal the total Contract Price.

10. Each item shall include a directly proportional amount of CONTRACTOR'S overhead and profit.
11. Schedule of Values shall show the purchase and delivery costs for materials and equipment that CONTRACTOR anticipates he shall request payment for prior to their installation.
12. Include a separate pay item for Maintenance of Plant Operations (MOPO) Work for each major Work area.
13. Include a separate pay item for: Construction Photographs; Temporary Facilities; Temporary Controls; Progress Schedule; General Conditions; and Field Engineering.
14. Include a separate pay item for all Allowances and Extra Unit quantities.
15. The Schedule of Values shall be prepared to a level of detail equal to or greater than required by the Supplementary Conditions.
16. The Schedule of Values shall be coordinated with the Resource/Cost Loading of the Progress Schedule provided in Section 01322, Progress Schedule (Cost Loaded CPM).

1.3 SUBMITTALS

A. Submit two copies of the Preliminary Schedule of Values to ENGINEER for review within 14 calendar days after the Notice to Proceed.

B. Submit two copies of the final Schedule of Values to ENGINEER for review within 20 days after the Notice to Proceed.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 01301

PRE-CONSTRUCTION CONFERENCE

PART 1 - GENERAL

1.1 DESCRIPTION

A. Date, Time and Location: Conference will be held after notice of award of the Contract. ENGINEER will coordinate with the OWNER to fix the date, time and location of the meeting, within 10 calendar days of notice of award.

B. ENGINEER shall prepare agenda, preside at meeting, and prepare and distribute a transcript of proceedings to all parties.

C. Provide data required, contribute appropriate items for discussion, and be prepared to discuss all items on agenda.

D. Unless previously submitted to ENGINEER, bring to the conference a preliminary schedule of each of the following:
   1. Progress Schedule.
   2. Shop Drawing and Sample submittals.
   3. Schedule of Values.
   4. A list of any items that require coordination or clarification from the OWNER and ENGINEER.

1.2 REQUIRED ATTENDANCE

A. Conference shall be attended by CONTRACTOR’S Project Manager, its superintendent and its major subcontractors and major equipment suppliers as CONTRACTOR deems appropriate.

B. OWNER'S representative.

C. ENGINEER.

D. Representatives of governmental agencies having any degree of control or responsibility, if available.

E. Utility company representatives.

1.3 PURPOSE

A. The purpose of the Pre-construction conference is to designate responsible personnel and establish working relationships. Matters requiring coordination will be discussed and procedures for handling such matters will be established. A complete agenda will be furnished to CONTRACTOR prior to the Pre-construction conference date. However, be prepared to discuss all of the following; but will not necessarily be limited to the following:

1. Designation of responsible personnel.
2. Subcontractors.
3. Coordination with other contractors and projects.
4. Progress schedule.
5. Processing of Shop Drawing Submittals.
6. Schedule of Shop Drawing submittals.
7. Processing of Field Orders, Requests for Information and Clarification and Change Orders.
8. Requirements for copies of Contract Documents.
9. Insurance in force.
10. Schedule of values.
11. Processing and Schedule of Payments.
12. Use of premises.
13. CONTRACTOR responsibility for safety and first aid procedures.
14. Site Security.
15. Housekeeping.
16. Field Offices.
17. Maintaining Record Drawings.
18. Letter of Notice to Proceed.
19. Permits.
20. Emergency Telephone Numbers.
21. Operation and Maintenance Manuals.
22. Temporary Utilities.
23. I&C Inspection & Testing Services Coordination
24. Electrical Arc Flash Coordination
25. Any other project related items.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 01311

PROJECT COORDINATION

PART 1 - GENERAL

1.1 DESCRIPTION

A. As more fully set forth in of the General Conditions, sole responsibility for coordination of all of the Work, belongs to CONTRACTOR. Supervise, direct and cooperate fully with all subcontractors, manufacturers, fabricators, suppliers, distributors, installers, testing agencies and all others whose services, materials or equipment are required to ensure completion of the Work within the Contract Time.

B. As more fully set forth in of the General Conditions, Cooperate with and coordinate the Work with the work of any other contractor, including the following, utility service companies or OWNER'S employees performing work at the site:
   1. Lift Station 66 Independent Electrical Feed

C. Not be responsible for damage done by contractors not under CONTRACTOR'S jurisdiction. Will not be liable for any such loss or damage, unless it is through the negligence of CONTRACTOR.

D. Coordinate the Work with the work of others to assure compliance with schedules.

E. Attend and participate in all project coordination or progress meetings and report on the progress of all Work and compliance with schedules.

F. Maintain sufficient competent personnel, drafting and CADD equipment and supplies at the site for the purpose of preparing layout, coordination and Record Drawings. These drawings shall supplement the Contract Documents, and the working and Shop Drawings as necessary to correlate the Work of various trades. Where such drawings are to be prepared by the mechanical, electrical, plumbing, or heating and ventilating subcontractors, ensure that each subcontractor maintains the required personnel and facilities at the site.

G. It is the duty of the CONTRACTOR to determine that all necessary permits have been obtained. The CONTRACTOR, at his own expense, obtain, maintain and close all the required permits which have not been furnished.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 01312

PROGRESS MEETINGS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Date and Time:
   1. Regular Meetings: Bi-weekly on a day and time agreeable to OWNER, ENGINEER and CONTRACTOR.
   2. Other Meetings: As needed and/or required in other specific specification sections.

B. Place: CONTRACTOR'S field office at Project site, or other mutually agreed upon location.

C. The ENGINEER shall conduct weekly progress meetings, record and distribute minutes of the meeting to all attendees and others as requested. At a minimum, the agenda will include: Requests for Information (RFI) and submittal status, past week's progress and a 3-week look-ahead schedule to include upcoming inspections, current issues, long lead items, critical issues and the next scheduled meeting date.

D. Provide data required and be prepared to discuss all items on agenda.

1.2 MINIMUM ATTENDANCE

A. CONTRACTOR:
   1. When needed for the discussion of a particular agenda item, require representatives of subcontractors or suppliers to attend a meeting.

B. ENGINEER.

C. OWNER'S representative, if required.

D. Others, as appropriate.

E. Representatives present for each party shall be authorized to act on their behalf.

1.3 AGENDA

A. Agenda will include, but will not necessarily be limited to, the following:
   1. Transcript of previous meeting.
   2. Progress since last meeting.

a. CONTRACTOR'S.
b. Subcontractors'.

3. Completion status.
4. Planned progress for next period including a 3-week look-ahead schedule to include upcoming inspections.
5. Document and track to correction and closure any problems, conflicts, issues, and observations that are voiced by anyone of the project team.
6. Status of Shop Drawings, submittals, long lead items, RFI and RFAs.
7. Change Orders.
8. Pay Requests.
9. Quality Standards and Control.
10. Schedules, updated Project Schedules, including off-site fabrication and delivery schedules; corrective measures, if required.
11. Coordination between parties.
12. Permits.
13. Safety concerns.
14. Construction Photographs.
15. Record Drawings.
16. Warranty Requests.
17. Punch List Status.
18. Other business.
19. Next meeting date.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 01321

PROGRESS SCHEDULE (CPM)

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section describes the Progress Schedule requirements to ensure that interim milestone dates will be met and completion of the Work will be accomplished within the time established. ENGINEER'S opinions concerning the various scheduling documents and reports are not controlling CONTRACTOR'S independent judgement concerning means, methods, and sequences of construction CONTRACTOR employs. Sole responsibility for meeting the Contract time(s) given in these Contract Documents, belongs to CONTRACTOR.

B. No later than 10 calendar days after the Notice to Proceed, submit a Preliminary Progress Schedule. The Preliminary Progress Schedule shall be referenced to time. The balance of Work leading to Substantial Completion of the Project shall be included, in a summary format.

C. No later than 15 calendar days after the Notice to Proceed, submit to the ENGINEER a 90-day Bar Chart Schedule prepared in accordance with Article 1.1 through 1.6, herein. The 90-day Bar Chart Schedule shall detail the first 90 calendar days of the Project.

D. No later than 20 calendar days after the Notice to Proceed, submit to the ENGINEER a full Progress Schedule prepared in accordance with Articles 1.1 through 1.7, herein. Upon review and acceptance, the CONTRACTOR'S submitted full progress schedule, described in this paragraph, will be deemed to be the "Baseline Schedule". (The use of the term "Baseline Schedule" refers to the early dates; the late dates are for the purpose of calculating float, and do not represent the schedule). This Baseline Schedule shall be used by the CONTRACTOR for planning, scheduling and executing the Work and for monitoring and reporting progress to the ENGINEER. No changes to the Baseline Schedule may be made by the CONTRACTOR without the approval of the ENGINEER.

E. To ensure completion of the Work within the contract times established, all of CONTRACTOR'S activities shall be scheduled and monitored by use of a Critical Path Method (CPM) Progress Schedule. Provide a CPM Schedule for Work done under this Contract, in accordance with this Section, and the sequence and progress of Work requirements included under Section 01110, Summary of Work, Section 01111, Schedule of Completion and Section 01143, Coordination with OWNER'S

Operations, the Supplementary Conditions and the Construction Sequence Diagram.

F. The Progress Schedule shall be prepared by CONTRACTOR using the Critical Path Method (CPM) utilizing the latest version of Primavera Project Planner software with Primavision (Primavera Project Planner and Primavision are U.S. registered trademarks of Primavera Systems, Inc., Bala Cynwyd, PA), or approved equal as determined by the OWNER and ENGINEER, conforming to the requirements hereinafter described.

1.2 SCHEDULING CONSULTANT

A. Engage, at his expense, a Scheduling Consultant or a qualified CONTRACTOR'S employee who has experience and is skilled in the time and cost application of CPM network techniques using Primavera on at least 5 construction projects to assist in the preparation of the Project Schedule. Prior to engaging a Scheduling Consultant or a qualified CONTRACTOR'S employee, Submit to the ENGINEER:
   1. The name and address of the proposed Scheduling Consultant or qualified CONTRACTOR'S employee and the names of those persons who would be dedicated to this Project.
   2. Sufficient information to show that the proposed Scheduling Consultant or qualified CONTRACTOR'S employee and the persons dedicated to this Project, have the qualifications to meet the Progress Schedule requirements.

B. The ENGINEER shall have the right to approve or disapprove the proposed Scheduling Consultant or qualified CONTRACTOR'S employee and will notify CONTRACTOR of his decision within (--2--) calendar days from receipt of information. In case of rejection, CONTRACTOR shall submit qualifications of another consultant within 14 calendar days for renewed considerations. Such approval or disapproval does not release CONTRACTOR from his obligations under this Contract.

1.3 LOGIC DIAGRAM

A. CONTRACTOR'S Scheduling Consultant or qualified CONTRACTOR'S employee shall prepare and submit a complete reproducible set of pure logic diagrams as generated by Primavera on 24-inch by 36-inch, or 11-inch by 17-inch drawings. The logic diagrams shall be grouped by Area and show the order and interdependence of activities and the sequence and quantities in which the Work is to be accomplished. Interrelationships to or from activities outside the area shown will be depicted by an activity symbol with activity number and description shown from the Primavera program. The basic concept of Precedence Diagramming Method (PDM) network scheduling shall be followed to show how the start of a given activity is dependent on the completion of preceding activities and how its completion may affect the start of following activities. The level of schedule detail

shall define the day-to-day activities of the construction Work. No construction activity duration shall be longer than Ten (10) working days without prior approval.

B. The critical path shall be distinguished from other paths on the network. The logic diagrams shall be banded by major work systems, including one system for procurement and by specific area within each system. Logic diagrams shall include the following:
   1. Activity number.
   2. Activity description.
   3. Activity duration (work days).
   4. Critical path denoted.
   5. Slack or float of each activity.
   6. System designation.
   7. Area code.
   8. Responsibility code (e.g., CONTRACTOR, subcontractors, trades, operations, suppliers, ENGINEER, or other party responsible for accomplishment of an activity).
   9. Shift number (if more than one shift per day is to be employed).

C. In addition to construction activities, network activities shall include the submittal and approval of samples of materials, shop and working drawings, and fabrication of special materials. It shall include all documents and proofs of compliance required by the Contract Documents for Final Inspection and Acceptance of the Work.

D. The Schedule Document shall include a System and Acceptance schedule within the project CPM schedule. This schedule will identify all equipment and systems that require testing, training and acceptance by the City of Phoenix. The durations and sequences of the systems testing and acceptance must be as specified in the various sections of the contract specification. Each system will contain, but will not be limited to, all of the following activities and constraints:
   1. Interface between the construction activities and their respective system.
   2. CONTRACTOR'S pre-testing work.
   3. Submittal and Approval of the CONTRACTOR'S Pre-testing Data and checklist, as appropriate.
   4. Sufficient notification time to the City of Phoenix prior to system testing.
   5. Submittal and Approval of the Preliminary and Final As-Built Drawings.
   6. Submittal and Approval of the Preliminary and Final O&M Manuals.
   7. Submittal and Approval of Testing Procedures.
   8. All other systems that are required to be tested and accepted prior to the specific system being tested.
   9. System Testing by the City of Phoenix.
   10. Other outside agencies, utilities, etc., that are required to test, witness and accept the system.

11. Submittal and Approval of the Training Syllabus, Training Manual, and Training Video.
12. Performance of Training.

E. All activities of the ENGINEER/OWNER that affect progress and special dates required by the Contract shall be shown.

1.4 MATHEMATICAL TABULATIONS

A. The mathematical tabulation of the network diagram shall include tabulation of each activity shown on the detailed network diagram.

B. The information listed below shall be furnished as a minimum for each activity. All submittal and updates shall consist of Three (3) copies of the reports described below and two sets of compact discs (CD's) containing Primavera schedule backups. The minimum required information includes:
   1. Activity number.
   2. Activity description.
   3. Activity duration (work days).
   4. Earliest start date (calendar date).
   5. Earliest finish date (calendar date).
   6. Latest start date (calendar date).
   7. Latest finish date (calendar date).
   8. Slack or float of each activity.
   9. Quantities involved for each construction activity with manhour requirements and dollar values.
   10. Critical path activities denoted.
   11. Work days calendar which extends for not less than the length of the contract, plus six months.

C. The mathematical tabulation shall be in the form of computer-generated reports. The reports shall be bound in booklet form, indexed, and separated by tabbed dividers. Computer-generated reports, of the following sorts, provided by CONTRACTOR:
   1. Milestone Report.
   2. Critical Path Activities Report by Early Start.
   3. Area Schedule Report for each System by Area/Early Start/Total Float.
   4. Responsibility Schedule Report for each System by Responsibility/Early Start/Total Float.
   5. 60-Day Look-Ahead Report by Area for Each System, then by activity number (with update line).
   6. Man-hour Resource Reports:
      a. Man-hour Summary by Responsibility.
      b. Monthly Projected Man-hour Flow Report (Tabular) with Manpower Resource Graphic on 24-inch by 36-inch, or 11-inch by 17-inch Sheet.

c. Man-hour Summary by Area.
d. Detailed Man-hour by Area/by Activity Report.

1.5 NARRATIVE REPORT

A. Prepare, and include with his original Progress Schedule submission, a narrative report describing the contract requirements and objectives and CONTRACTOR'S plan and schedule for achieving those requirements and objectives. The narrative shall describe the methods of operation, the resources to be employed, time frames for the construction of each of the major systems on the project, and time frames for accomplishment of the specified milestones and project completion.

B. It shall also include, but not be limited to:
1. A justification and identification of activities that were worked out of sequence.
2. A description of problem areas.
3. Current and/or anticipated delaying factors and their potential impact.
4. An explanation of corrective action (recovery plan) either taken or proposed for all critical areas.
5. A listing of al intermediate contractual milestones with their respective float and schedule analysis.
6. Define activities that were not started or completed as scheduled and provide explanation.
7. Identify and discuss planned manpower versus actual manpower usage and provide projections by Subcontractor.
8. Identify outstanding "Requests for Information (RFI's)" and discuss their schedule impact.

1.6 MAN-HOURS LOADING REPORTS

A. After acceptance of the original Progress Schedule, assign labor resources to each construction activity within each responsibility code in man-hours. Resource schedule reports will be required and resource leveling may be employed as required.

1.7 PROGRESS SCHEDULE SUBMITTAL

A. No later than 10 calendar days after the Notice to Proceed, submit to the ENGINEER a 90-day Bar Chart Schedule. During this period CONTRACTOR and the Scheduling Consultant shall meet with the ENGINEER and the OWNER for a minimum of a 2-hour workshop sessions to review technical requirements and schedule development methods and procedures. The 90-day Bar Chart Schedule will be reviewed by the ENGINEER within 14 calendar days of receipt or request for adjustment. A meeting, or meetings, may be required with CONTRACTOR'S Scheduling Consultant during this period in order to expedite acceptance or

adjustment. Any adjustments required after this period shall be made and resubmitted by CONTRACTOR within 14 calendar days.

B. No later than 30 calendar days after the Notice to Proceed, 14 calendar days after the complete Progress Schedule has been accepted by the ENGINEER, CONTRACTOR submit to the ENGINEER a full Progress Schedule prepared in accordance with Articles 1.1 through 1.5, above. During this period the ENGINEER, CONTRACTOR and CONTRACTOR'S Scheduling Consultant shall meet biweekly to review the progress of the development of the full Progress Schedule. Lack of progress in the development of the Progress Schedule shall be cause for suspension of any Progress Payment. The complete Progress Schedule will be reviewed by the ENGINEER within 14 calendar days of receipt or request for adjustment. A meeting, or meetings, may be required with CONTRACTOR'S Scheduling Consultant during this period in order to expedite acceptance or adjustment. Any adjustments required after this period shall be made and resubmitted by CONTRACTOR within 14 calendar days.

C. No later than 14 calendar days after the complete Progress Schedule has been accepted by the ENGINEER, CONTRACTOR submit to the ENGINEER a CPM Progress Schedule with man-hours in accordance with Articles 1.4 and 1.6, above. The Progress Schedule shall be reviewed by the ENGINEER within 14 calendar days of receipt or request for adjustment. Any adjustments required after this period shall be made and resubmitted by CONTRACTOR within 14 calendar days.

D. If, in the preparation of the Progress Schedule, CONTRACTOR reflects a completion date or milestone date different than that specified in the Contract, this in no way voids the dates set therein. The dates as specified in the Contract govern. Where the Progress Schedule reflects a completion date or milestone date earlier than specified, the ENGINEER may accept such schedule with CONTRACTOR specifically understanding that no claim for additional Contract Time or compensation shall be brought against the OWNER as the result of failure to complete the Work by the earlier date shown on the Progress Schedule.

1.8 FAILURE TO SUBMIT

A. Should CONTRACTOR fail to submit the Progress Schedule in the form indicated within the required time frames shall be cause for suspension of any Progress Payment.

1.9 UPDATING THE PROGRESS SCHEDULE

A. Updates:
   1. Monthly updates to the mathematical tabulation are the CONTRACTOR'S responsibility. The updated mathematical tabulation shall include the following data for each activity:

a. Actual start date (for started activities).
b. Actual finish date (for completed activities).
c. Percent complete.
d. Current projected early/late start/finish dates (for activities not started).
e. Current early/late finish dates (for uncompleted activities).
f. Current Total float.
g. Critical path activities noted.

2. CONTRACTOR'S Schedule Update shall include a narrative report which shall include a description of the current progress/status of each area of the project, a description of the progress for the period, a description of the critical path, a discussion of current or potential delays, Change Orders (pending or approved), or other problems.
3. Provide the ENGINEER with five updated hard copies of schedule data and two software backup copies on CD's. Network diagrams shall be submitted with the tabulation if there are any proposed revisions to network logic, interim milestones, contract completion, or as directed by the ENGINEER. The updated tabulations shall reflect the current status of activities, as outlined on the baseline network diagram. The updated tabulation reports shall reflect all changes in dates, remaining durations, and float time. If any delays have occurred, these shall be noted for time consideration.

B. Monthly Schedule Meeting:
1. Recording the start and completion dates of each scheduled work activity with the remaining duration for activities started but not completed, including procurement activities is the CONTRACTOR'S responsibility. On one day each month, at least one week prior to the monthly progress meeting, CONTRACTOR and the Scheduling Consultant shall meet with the ENGINEER to tour the site and review and updated information gathered by CONTRACTOR during the month. After acceptance of CONTRACTOR'S updated data, CONTRACTOR'S Scheduling Consultant shall use this information to update the mathematical tabulations and to generate a Monthly Schedule Update.

C. Network Revisions:
1. Conditions may develop that require revisions to logic or durations of the original network. If during the progress of the Work events develop that necessitate changes in the original Progress Schedule, propose such changes so as to depict the current mode of operation and provide the ENGINEER with a revised network diagram. Any revision to the original logic or original durations must be accepted by the ENGINEER, in writing. After acceptance, logic/duration revisions will be incorporated into the Progress Schedule and will be addressed in the monthly narrative report by means of both a description of the revisions and a listing of those network elements affected by such change. All changes resulting from Change Order(s), additions or deletions, will be fully incorporated into the Progress Schedule on the first

update after the Change Order approval, including all adjustments to the man-hours.

2. Revisions and additions to the accepted network diagrams and mathematical tabulations shall be submitted in three (3) copies of the reports, two (2) software back-up copies on CD of the schedule and a reproducible set of the 24-inch by 36-inch pure logic diagrams.
3. The list of revisions and additions will include the following, when applicable:
   a. Addition and deletion of activities.
   b. Addition and deletion of relationships.
   c. Changes to activity descriptions and durations.
   d. Changes to relationship types and lag codes.
   e. Changes to contract milestone dates and approved constraint dates.
   f. Changes to dollar values resulting from approved Change Orders.
   g. All other revisions to the network logic.

1.10 TIME IMPACT ANALYSIS FOR CHANGE ORDERS, DELAYS, AND TIME EXTENSIONS

A. Change Orders, Delays, and Time Extensions:
   1. When a Change Order(s) is (are) proposed by the ENGINEER or CONTRACTOR, or delays are experienced, submit a Time Impact Analysis (TIA) illustrating the influence of each Change Order or delay on any specified intermediate milestone date(s) or contract completion date. Each TIA shall include a sketch (fragnet) demonstrating how CONTRACTOR proposes to incorporate the change(s) or delay(s) into the current Progress Schedule. The fragnet will include all logic changes and additions required because of said Change Order(s) or delay(s).
   2. This fragnet will show all CPM Logic revisions for the Work in question and its relationship to other activities in the network plan. Additionally, the analysis shall demonstrate the time impact, based on the date the change was given to CONTRACTOR, the status of construction at that point in time, and the activity duration of all affected activities. The activity duration used in this analysis shall be those included in the latest update of the Progress Schedule, closest to the time of delay as adjusted by mutual agreement in writing.

B. Submission:
   1. Each Time Impact Analysis shall be submitted within 7 calendar days after a delay occurs or a notice of change or Change Order is given to CONTRACTOR. In cases where CONTRACTOR does not submit a Time Impact Analysis for a specific change or delay within the specified period of time, it shall be mutually agreed that no time extension is required.

C. Evaluation:
   1. Final evaluation of each Time Impact Analysis by the ENGINEER shall be made within 7 calendar days after receipt, unless subsequent meetings and

negotiations are necessary. Adjustments in the Contract time for performance shall be made only by written Change Order. Upon acceptance by the ENGINEER, fragnets illustrating the influence of changes and delays shall be incorporated into the current schedule by CONTRACTOR during the first update after agreement is reached.

2. The time difference between the Early Finish date and the Late Finish date is defined as "float." The "float" belongs to the Project and may be used by CONTRACTOR or the OWNER to benefit the Project. Changes or delays that influence activities in the network with "float" and do not extend the Critical Path (the sequence of activities with zero days float) shall not be justification for an extension of Contract time for performance.

1.11 RECOVERY SCHEDULE

A. In the event that the Progress Schedule update mathematical analysis indicates that the Project, or progress towards any interim milestone requirement, falls 10 or more work days behind schedule and there is no excusable delay or change to support a time extension, prepare and submit a Recovery Schedule for acceptance by the ENGINEER. Also, revise logic or durations to cause the mathematical analysis to show the Project on schedule. The Recovery Schedule shall be submitted five (5) calendar days after the Progress Schedule Update is submitted.

B. Provide additional manpower, equipment, or materials or work additional shifts, or expedite procurement to complete activities within the accepted intermediate or Contract completion dates, at no additional cost the OWNER. Upon acceptance of the Recovery Schedule by the ENGINEER, incorporate the Recovery Schedule into the current Progress Schedule.

C. Lack of Action:
   1. CONTRACTOR'S refusal, failure, or neglect to take appropriate recovery action or to submit a written recovery statement shall constitute reasonable evidence that CONTRACTOR is not prosecuting the Work, or separable part, with the diligence that will ensure its completion within the applicable Contract time. Such lack of action shall constitute sufficient basis for the ENGINEER to recommend the withholding of some or all of any payment due, or shall be considered grounds for termination by the OWNER.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 01323

CONSTRUCTION PHOTOGRAPHS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Retain a professional photographer or an acceptable person, as determined by the ENGINEER, to perform the services specified below.

B. Obtain ENGINEER'S approval of the photographer selected prior to taking first photographs. Submit qualifications and experience record of photographer to ENGINEER.

1.2 PHOTOGRAPHS

A. CONTRACTOR shall take daily color digital photographs daily to document the Work.

B. CONTRACTOR shall take color digital photographs of the completed or substantially completed Work at Project Completion. These photographs shall be submitted with the Final Application for Payment. These photographs are not part of the photographs required under Paragraph 1.2.A., above.

C. The CONTRACTOR shall take color digital photographs daily of all underground work in progress; work being done that will be exposed above ground shall be photographed on a bi-weekly basis. Photographs shall be taken in such a way to include an area or directional landmark. A minimum of five overall general project photographs depicting the over all project activities shall be taken monthly. A photograph log shall be maintained throughout the project with the following information for each photo: photograph number, a brief description, date, job title, location or station of pipeline (if applicable), and direction of the view in the photograph. The CONTRACTOR shall submit a plan that illustrates how the photograph log will be organized for approval by the OWNER.

D. ENGINEER will approve the views to be taken and select the time at which they will be taken. All photographs need to be viewable (digital) in a file format approved by the ENGINEER and OWNER, otherwise they will not be allowed off-site (refer to paragraph 1.4.A). Views will vary depending on the Progress Schedule.

E. A minimum of three color digital photographs will be taken each time the photographer is at the site.

F. Submit aerial photographs of the site with Initial and Final Application for Payment. One oblique photograph shall be taken from each cardinal direction (North, South, East, and West). Provide 2 digital copies of each. One copy for the ENGINEERS use and the other to be turned over to the OWNER.

1.3 PRINTS

A. Furnish three prints of each photograph to the ENGINEER with each Monthly Progress Payment.

B. Furnish additional photographs or prints requested by ENGINEER at cost. Maximum number of printed photographs required will be ten.

C. Provide high quality 5-inch by 7-inch standard weight prints with a satin finish. Aerial photographs shall be at least 20 by 24-inches, standard weight prints with a satin finish.

D. Provide high quality digital photographs on CDs. The file format shall be "jpg" or other format approved by the OWNER and ENGINEER. The digital photographs shall be provided in addition to the standard photographs required under Paragraph 1.3.C., above. Need to provide a file for all required under paragraph 1.2.A.

E. Provide interior and exterior photographs of each buried structure prior to burial. Provide a minimum of four internal views and four external views of each structure. One view shall be provided of each wall, detail, floor and top of structure.

F. Place the following information on the back of each print and on front for digital photographs:
   1. Date photograph was taken.
   2. Title of Project, WS #.
   3. Description of view shown in photograph.
   4. North Arrow reference.

1.4 PRE-CONSTRUCTION PHOTOGRAPHS

A. Policy
   1. Photography on facility grounds is strictly controlled. All personnel must submit a written application request to Water Services Department, Security Management Unit for photography and receive written permission. Application must include name of company, the photographer, and area of interest. If written application is not submitted prior to the commencement of photography activities, on-site security personnel will stop the activities, confiscate the media materials and notify the Security Management Unit.
   2. Once permission is received, the OWNER must be notified before photos or videotapes are made.

3. Prior to departing from the site, photographer must have the materials reviewed by either the Facility Supervisor or the O&M Supervisor. For media that's not readily viewable, such as film that needs to be developed, the photographer must allow the Facility Supervisor or O&M Supervisor to review the materials prior to any use of the materials.

B. General

1. It is the CONTRACTORS responsibility to provide pre-construction photographs or construction photographs during the Work, so as to resolve any disputes which may arise regarding the considerations prior to and subsequent to construction, belongs to CONTRACTOR.
2. If a dispute arises where no Pre-construction photographs were provided, the disputed area shall be restored to the extent directed by the ENGINEER and to the complete satisfaction of the ENGINEER.
3. Prior to the start of any construction activities the CONTRACTOR shall furnish (2) sets of color pre-construction photographs and video for approval; one for the ENGINEER and one for City of Phoenix.
4. Pre-construction photographs taken by CONTRACTOR will not be considered as part of the required number of construction photographs required in Paragraph 1.2, above.
5. A high quality video of the site in digital format approved by the ENGINEER and OWNER shall be made and submitted by the CONTRACTOR.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 01330

SUBMITTALS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Submittal of documents described in the General Conditions, Supplementary Conditions and hereinafter are required prior to, during and at the end of the construction period. The submittals shall conform to the requirements described in this Section and all referenced Sections or Articles.

1.2 GENERAL SUBMITTAL REQUIREMENTS

A. A submittal shall be made for each complete system. Piecemeal submittals will not be accepted.
B. Submittals requiring ENGINEER review only will be processed within 15 calendar days after receipt from the CONTRACTOR. Complicated submittals such as submersible pumps, biofilter odor control systems, motor control centers, and control systems will be processed within 30 calendar days after receipt from the CONTRACTOR. Submittals requiring ENGINEER and OWNER review will be processed within 30 calendar days after receipt from the CONTRACTOR.
C. CONTRACTOR shall maintain a file of all approved submittal documents at the work site.
D. CONTRACTOR shall show his executed internal review and approval marking. Submittals which are received from sources other than through CONTRACTOR'S Office or which have not undergone CONTRACTOR review will be returned "Rejected".

1.3 PROCEDURE

A. Submittals within 14 calendar days after the Notice to Proceed: Submit the following items within 30 calendar days after the Notice to Proceed. Location of information concerning each submittal is referenced and a copy of each required form is included in Section 01331, Reference Forms.
   1. Preliminary Schedule of Values: Prepare and submit in accordance with Section 01291, Schedule of Values.
   2. Preliminary Schedule of Shop Drawings and Sample Submittal in accordance with the General Conditions and Section 01332, Shop Drawing Procedures.
   3. Preliminary Progress Schedule: Prepare and submit in accordance with Section 01321 - Progress Schedule CPM.

B. Submittal within 30 calendar days after the Notice to Proceed: Submit the following items within 30 calendar days after the Notice to Proceed. Location of

information concerning each submittal is referenced and a copy of each required form is included in Section 01331, Reference Forms.

1. Schedule of Values: Prepare and submit in accordance with Section 01291, Schedule of Values.
2. Submittal Schedule: Prepare and submit schedule of all Shop Drawings in accordance with Section 01332, Shop Drawing Procedures.
3. Monthly payment schedule.
4. Maintenance of Plant Operations Schedule, in accordance with Section 01143, Coordination with OWNER'S Operations.
5. Ninety-day Bar Chart Schedule: Prepare and submit a 90-day Bar Chart Schedule within 30 calendar days, in accordance with Section 01321-Progress Schedule CPM.

C. Submit the following items within 30 calendar days after the Notice to Proceed. Location of information concerning each submittal is referenced and a copy of each required form is included in Section 01331, Reference Forms.
   1. Progress Schedule: Prepare and submit a Progress Schedule within 30 calendar days, in accordance with Section 01321 -Progress Schedule CPM.

D. Submit the following items at the Pre-construction Conference: Refer to Sections 01332, Shop Drawing Procedures, and Section 01521, ENGINEER'S Field Office.

E. Submittals Prior to Beginning the Work: Refer to the General Conditions and Supplementary Conditions of the Contract Documents.

F. Submittals During Construction: During progress of the construction, provide the following submittals in a timely manner to prevent any delay in the Work schedule:
   1. Updates to Progress Schedule: Provide an assessment of Work progress in relation to the Progress Schedule in accordance with Section 01321- Progress Schedule CPM.
   2. Shop Drawings, Product Data and Samples: Submit Shop Drawings, product data and samples in accordance with Section 01332, Shop Drawing Procedures, and as required in various Sections of the Contract Documents.
   3. Progress Payments: Submit applications for partial payments as specified in the General Conditions. MBE/WBE Utilization Form, included in Section 01331, Reference Forms, shall be submitted with each progress payment.
   4. Request for Information: Submit a Request for Information (RFI), included in Section 01331, Reference Forms, when any of the following are required: an interpretation of the Specifications; additional details; information not shown on the Drawings or in the Specifications; or clarification of discrepancies is needed. Retain one copy and submit one hard copy and one electronic PDF format copy to the ENGINEER for response. Once the RFI is commented on by the ENGINEER, an electronic PDF format copy will be forwarded to the OWNER.

5. Change Orders: Forms shown in Section 01331, Reference Forms. A proposal for a Change Order may be submitted by CONTRACTOR in accordance with the General Conditions. The Change Order Proposal included in Section 01331, Reference Forms, must be in writing and must include sufficient information to assess the need for a change in the Work, the Contract time or the Contract amount. Whenever the ENGINEER determines the need for a Change Order, a Request for Change Order Proposal Form included in Section 01331, Reference Forms, will be issued to CONTRACTOR. Upon receipt of a Request for Change Order Proposal Form or when CONTRACTOR determines the need for a Change Order, prepare and submit three copies of a Change Order Proposal. The Change Order Proposal must be approved by CONTRACTOR, ENGINEER, and OWNER. When a Change Order Proposal has been accepted, a Work Change Directive shall be submitted. Each Work Change Directive shall include a Change Order Pricing Sheet, included in Section 01331, Reference Forms. After the Work Change Directive has been accepted by the OWNER, a Change Order included in Section 01331, Reference Forms, will be prepared and executed. Not authorized to begin work on a Change Order until it is fully executed. Any Work done by CONTRACTOR prior to execution of a Change Order is entirely at his own risk.
6. Use of CONTRACTOR'S Contingency: Shown in Section 01331, Reference Forms: Submit the CONTRACTOR'S Contingency Usage Request including a description for use of the contingency and costs associated for review by the ENGINEER and acknowledgement by the OWNER.
7. CONTRACTOR'S Daily Report: Shown in Section 01331, Reference Forms: Submit four copies of CONTRACTOR'S Daily Report. CONTRACTOR and each subcontractor shall prepare and submit a daily report on forms shown in Section 01331, Reference Forms. The report shall contain, as a minimum, information on the location and description of the Work being performed, size, quantity and description of materials and equipment installed or delivered, coordination or scheduling concerns, requests for clarifications, and any discrepancies noted in the Contract Documents or on the as-built conditions. The report shall also contain CONTRACTOR'S daily workforce count by craft, general weather conditions, any Work performed other than during established working hours, and any other pertinent items relative to the Work, and as required by ENGINEER. The report is due at the ENGINEER'S office by 9:00 a.m. on the following Work day and shall be signed by a responsible member of CONTRACTOR'S staff.
8. Submittal Schedule: Shown in Section 01331, Reference Forms. Submit an updated Shop Drawing, Product Data and Sample Submittal Schedule with each Progress Payment Request. Three updated Submittal Schedules shall be submitted with each month's Progress Payment Request.
9. Construction Photographs: Submit Construction Photographs and Aerial Photographs with each month's Progress Payment Request as specified in Section 01323, Construction Photographs.

10. Operation and Maintenance Manuals and Lesson Plans: Submit Equipment Operation and Maintenance Manuals for approval, by the ENGINEER, within 30 days after approval of Equipment Shop Drawing. Submit Equipment Training Lesson Plans for approval, by the ENGINEER, 60 days prior to commencement of training. Submit Operation and Maintenance Data and Lesson Plans in accordance with Section 01781, Operation and Maintenance Data and Section 01821, Instruction of Operations and Maintenance Personnel.
11. Submit test procedures for Start up, Burn-in, Field Operations Checks and Commissioning a minimum of 14 calendar days prior to commencement of the first scheduled test date. The CONTRACTOR should allow up to 14 calendar days for ENGINEER'S review.

G. Submittal at Substantial Completion: Submit all Operations and Maintenance Data for each item of Work commissioned into operation.

H. Submittal At Project Closeout: With a written Notice of Completion, submit the following items in the proper form as a condition of Final Acceptance of the Work:
   1. Project Record Documents: Submit in accordance with Section 01782, Record Documents.
   2. Guarantees, Warranties and Bonds: Submit as required in the General Conditions and listed in various Sections of the Specifications, and Section 01781, Operation and Maintenance Data.
   3. Operations and Maintenance Data: Submit all remaining product data, field test data and manuals as specified in various Sections of the Specifications, and Section 01781, Operation and Maintenance Data.
   4. Survey notes.
   5. Construction photographs of all completed Work, in accordance with Section 01323, Construction Photographs.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 01332

SHOP DRAWING PROCEDURES

PART 1 - GENERAL

1.1 DESCRIPTION

A. The submittal of Shop Drawings shall conform to requirements of General Conditions and procedures described in this Section. A separate transmittal form shall be used for each specific item or class of material or equipment for which a submittal is required. Transmittal of Shop Drawings on various items using a single transmittal form shall be permitted only when the items taken together constitute a manufacturer's "package" or are so functionally related that expediency indicates review of the group or package as a whole.

B. The term "Shop Drawings" as used herein shall be understood to include detailed design calculations, fabrication and installation drawings, lists, graphs, test data, operating instructions, and other items which shall include, but are not necessarily limited to:
   1. Drawings and catalog information and cuts.
   2. Specifications, parts list, suggested spare parts lists, and equipment drawings.
   3. Wiring diagrams of systems and equipment.
   4. Complete lubrication, maintenance and operation instructions, including initial startup instructions as described in Section 01821- Instruction of Operations and Maintenance Personnel.
   5. Applicable certifications.
   6. Anchor bolt templates, mounting instructions and mounting design calculations as required.
   7. Required maintenance operations to allow all installed equipment to remain idle for a period of time not to exceed 24 months.
   8. Other technical, installation, and maintenance data as applicable.
   9. Unloading and handling methods and storage requirements.
   10. Note, highlight, and explain proposed changes to the Contract Documents.
   11. Paint submittal showing type of paint and the mils thickness of coating system used. The coating system shall be the approved system as submitted under Division 9, Finishes.
   12. Drawings showing CONTRACTOR field verifications illustrating all field dimensions. Field verify all dimensions and existing materials shown on the Drawings. Any modifications required shall be at CONTRACTOR'S expense.
   13. Materials or products which can contact drinking water as part of a Water Treatment Process or Water Supply System.

C. Preliminary Submittal Schedule: CONTRACTOR, within 14 calendar days after the Notice to Proceed, shall prepare and submit to the ENGINEER a Preliminary

Submittal Schedule. Identify on his Preliminary Submittal Schedule all of the submittal items required by the Contract Documents governing the Work.

D. Submittal Schedule: CONTRACTOR, within 30 calendar days after the Notice to Proceed, shall prepare and submit to the ENGINEER a comprehensive Submittal Schedule. Identify on his Submittal Schedule all of the submittal items required by the Contract Documents governing his Work. Indicate, for each submittal item on his Submittal Schedule the following:

1. The date by which that item will be submitted to the ENGINEER.
2. Whether the submittal is for a substitute or "equal" item. Complete submittal for all substitute or "equal" items shall be made to the ENGINEER, in accordance with the Contract requirements. Identification by the CONTRACTOR of substitute or "equal" items does not relieve CONTRACTOR of his responsibility to furnish equipment and materials that meet all the requirements of the Contract Documents. Items of manufacturers' equipment listed with CONTRACTOR'S Bid Proposal shall not be replaced with any substitute or "equal" items as part of this Submittal Schedule process. Procedure for substitutions is specified under the General Conditions.
3. Whether the submittal is for review or "for record only".
4. The date by which response is required.
5. The date by which the material or equipment must be on site in order not to delay the progress of the Work.

In preparing his Submittal Schedule, consider the nature and complexity of each submittal item and shall allow ample time for review, revision or correction. Submittal will normally be returned to CONTRACTOR within 15 calendar days following receipt of the submittal. Complex submittals, for example, submersible pumps, odor control systems, Instrumentation and Control Systems, Variable Frequency Drives and other such submittals may require additional review time up to 30 calendar days. Identify submittal(s) for which long review periods are anticipated.

F. Hereby notified that the project electric motor requirements, specified in Section 11000, Electric Motors, do not allow standard "off the shelf" motors. Make provisions in the Submittal Schedule to account for longer manufacturing and delivery lead times for the motors and equipment requiring electric motors under this Project.

The ENGINEER will review CONTRACTOR'S Submittal Schedule to determine its completeness and compatibility with the Progress Schedule. A Submittal Schedule which is incompatible with the Progress Schedule or a review schedule which places extraordinary manpower demands on the ENGINEER will be sufficient reason(s) to reject the Submittal Schedule. It shall be understood that certain submittals will require up to 30 calendar days to review and that these particular submittals will be identified during the review of the Submittal Schedule, by the

ENGINEER to allow for very complex submittal reviews. Also, identify submittal for which he anticipates long review periods.

CONTRACTOR'S Submittal Schedule shall be consistent with the Progress Schedule as described in Section 01321 - Progress Schedule CPM.

Approval of the Submittal Schedule shall be required prior to processing of the first progress payment.

1.2 PROCEDURE

A. Submit Shop Drawings to: The ENGINEER or the OWNER's Designated Project Representative.

B. A letter of transmittal shall accompany each submittal. If data for more than one Section of the Specifications is submitted, a separate transmittal letter shall accompany the data submitted for each Section.

C. All letters of transmittal shall be submitted in duplicate.

D. At the beginning of each letter of transmittal, provide a reference heading indicating the following:
   1. OWNER'S Name _____
   2. Project Name _____
   3. Contract No. _____
   4. Transmittal No. _____
   5. Section No. _____

E. If a Shop Drawing deviates from the requirements of the Contract Documents, specifically note each variation in his letter of transmittal.

F. All Shop Drawings submitted for approval shall have a title block with complete identifying information satisfactory to ENGINEER.

(The remainder of this page was left blank intentionally.)

G. All Shop Drawings submitted shall bear the stamp of approval and signature of CONTRACTOR as evidence that they have been reviewed and verified to the completeness of the submittal by CONTRACTOR. Submittal without this stamp of approval will not be reviewed by ENGINEER and will be returned to CONTRACTOR. CONTRACTOR'S stamp contain the following minimum information:

Project Name: _____

CONTRACTOR'S Name: _____

Date: _____

----------Reference----------

Item: _____

Specifications:

Section: _____

Page No.: _____

Para. No.: _____

Drawing No.: _____ of _____

Location: _____

Submittal No.: _____

Approved By: _____

H. To identify and track all submittals as separate and unique items, utilize the submittal identification numbering system as follows:

1. The Submittal Number shall be a separate and unique number correlating to each individual submittal that is required to be tracked as a separate and unique item. The Submittal Number shall be a two part, eight character, alpha/numeric number assigned by CONTRACTOR in the following manner:
    a. The first part of the Submittal Number shall consist of five characters that pertain to the applicable Specification Section number.
    b. The second part of the Submittal Number shall consist of three digits (numbers 001 to 999) to number each separate and unique submittal submitted under each Specification Section.
    c. A dash shall separate the two parts of the Submittal Number.
    d. A typical Submittal Number for the third Working Drawing submitted under Section 15101, Ductile Iron Pipe, would be 15101-003.

2. The Review Cycle shall be a three-digit number indicating the initial submission or resubmission of the same submittal. For example:

   001 = First (initial) submission
   002 = Second submission (first resubmission)
   003 = Third submission (second resubmission)

3. An example of the typical submittal identification numbers for the first submission of the third submittal submitted under Section 15101, Ductile Iron Pipe is:

Submittal Number	Review Cycle
15101-003	001

3. An example of the typical submittal identification numbers for the second submission of the third submittal submitted under Section 15101, Ductile Iron Pipe is:

Submittal Number	Review Cycle
15101-003	002

I. Initially submit to ENGINEER a minimum of five HARD copies and one Electronic PDF format copies.

J. After ENGINEER completes his review, Shop Drawings will be affixed with a stamp and marked with one of the following notations:
   1. Approved.
   2. Approved as Corrected.
   3. Approved as Corrected, Resubmit.
   4. Revise and Resubmit.
   5. Not Approved.
   6. Not Reviewed.
   7. For Information Only.

K. If a submittal is acceptable, the ENGINEER will mark it “Approved” or “Approved as Corrected” and will forward one electronic PDF format of the submittal to the OWNER for review and comment. The OWNERS review process will begin when all required copies of a specific submittal are received. After the OWNERS review is complete, the ENGINEERS and OWNERS comments will be combined and one electronic PDF version of the submittal will be returned to CONTRACTOR.

L. Upon return of a submittal marked "Approved" or "Approved as Corrected", CONTRACTOR may order, ship or fabricate the materials included on the submittal, provided it is in accordance with the corrections indicated.

M. If a Shop Drawing marked "Approved as Corrected" has extensive corrections or corrections affecting other Shop Drawings or Work, ENGINEER may require that CONTRACTOR make the corrections indicated thereon and resubmit the Shop Drawings for record purposes. Such Shop Drawings will have the notation, "Approved as Corrected - Resubmit." The corrected Shop Drawing shall be a pre-condition for payment for the work item of the Shop Drawing.

N. If a submittal is unacceptable, one electronic PDF version will be returned to CONTRACTOR with one of the following notations:
1. "Revise and Resubmit"
2. "Not Approved"

O. Upon return of a submittal marked "Revise and Resubmit", make the corrections indicated and repeat the initial approval procedure. The "Not Approved" notation is used to indicate material or equipment that is not acceptable. Upon return of a submittal so marked, repeat the initial approval procedure utilizing acceptable material or equipment.

P. Any related Work performed or equipment installed without an "Approved" or "Approved as Corrected" Shop Drawing will be at the sole responsibility of CONTRACTOR.

Q. Shop Drawings shall be submitted well in advance of the need for the material or equipment for construction and with ample allowance for the time required to make delivery of material or equipment after data covering such is approved. Assume the risk for all materials or equipment which are fabricated or delivered prior to the approval of Shop Drawings. Materials or equipment will not be included in periodic progress payments until approval thereof has been obtained in the specified manner.

R. ENGINEER will review and process all submittals promptly; a reasonable time shall be allowed for this, for the Shop Drawings being revised and resubmitted, and for time required to return the approved Shop Drawings to CONTRACTOR.

S. Responsibility belongs to CONTRACTOR to review submittals made by his suppliers and subcontractors before transmitting them to the ENGINEER to assure proper coordination of the Work and to determine that each submittal is in accordance with CONTRACTOR'S desires and that there is sufficient information about materials and equipment for ENGINEER to determine compliance with the Contract Documents. Incomplete or inadequate submittals will be returned for revision without review.

T. Furnish required submittals with complete information and accuracy in order to achieve required approval of an item within one submittal. Backcharges for resubmittals that account for a number greater than 20 percent of the total number of first time submittals and will be backcharged for all third submittals. The number of first time submittals shall be equal to the number of submittals agreed to by ENGINEER and CONTRACTOR in accordance with Section 01330.1.2.A.2. All costs to ENGINEER involved with subsequent submittal of Shop Drawings, Samples or other items requiring approval will be backcharged to CONTRACTOR at the rate of 3.0 times direct technical labor cost by deducting such costs from payments due CONTRACTOR for Work completed. In the event that CONTRACTOR requests a substitution for a previously approved item, all of ENGINEER'S costs in the reviewing and approval of the substitution will be backcharged to CONTRACTOR, unless the need for such substitution is beyond the control of CONTRACTOR.

U. The OWNER reserves the right to withhold monies, identified in the General Conditions, for Shop Drawing reviews beyond those described herein.

The ENGINEER will implement, if requested by CONTRACTOR, one special Shop Drawing Review Meeting. The purpose of the meeting is to expedite Shop Drawing reviews for the equipment and materials required for the first document of the Work. Requirements of this Section will not be waived, but could be expedited.

W. Mark each page of a submittal and each individual component submitted with the specification number, paragraph, and subparagraph. Arrange submittal information presentation to appear in the sequence in the Specification Section.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 01333

SAMPLES

PART 1 - GENERAL

1.1 DESCRIPTION

A. The submittal of Samples shall conform to the requirements of the General Conditions and to procedures described in this Section.

B. Samples and Shop Drawings which are related to the same unit of Work or Specification Section shall be submitted at the same time. If related Shop Drawings and Samples are submitted at different times, they cannot be reviewed until both are furnished to the ENGINEER.

1.2 PROCEDURE

A. Review, approve, and submit all Samples promptly. Samples shall be identified with correct reference to Specification Section, page, article and paragraph number, and Drawing Number, when applicable. Samples shall clearly illustrate functional characteristics of the product, all related parts and attachments, and full range of color, texture, pattern and material. Samples shall be furnished so as not to delay fabrication, allowing the ENGINEER reasonable time for the consideration of the Samples submitted.

B. Submit at least three Samples of each item required for the ENGINEER'S approval. Submission of Samples shall conform to all applicable provisions under Shop Drawing Submittal and Correspondence Procedure. Two of the Samples shall be delivered to the OWNER's office address unless otherwise authorized by the ENGINEER. The ENGINEER shall retain all samples. If CONTRACTOR requires a Sample for his use, he shall notify the ENGINEER, in writing.

C. Make all corrections required and shall resubmit the required number of new Samples, until approved.

1.3 JOB MOCK-UPS

A. Job mock-ups (sample panels) shall be constructed on site by CONTRACTOR and only one of each type will be required. Mock-ups shall be constructed only after the individual Samples and components used in the mock-up have been approved by the ENGINEER. If a mock-up is not approved, construct additional ones until approval is received.

B. Store and protect large Samples and mock-ups until the Work is complete or until a time approved by ENGINEER.

1.4 SAMPLES FOR TESTS

A. Furnish such Samples of material as may be required for examination and tests. All Samples of materials for tests shall be taken according to standard methods and as required by the Contract Documents.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 01412

STORMWATER POLLUTION PREVENTION PLAN AND PERMIT

PART 1 - GENERAL

1.1 DESCRIPTION

A. Comply with the terms and conditions of the Arizona Pollutant Discharge Elimination System (AZPDES) requirements under the Arizona Department of Environmental Quality (ADEQ) General Permit. Under provisions of that permit, CONTRACTOR is designated as permittee and responsible for providing necessary material and for taking appropriate measures to minimize pollutants in stormwater runoff from the Project. Obtain a DeMinimus discharge permit from ADEQ for any discharge that is to Waters of the U.S., and comply with the requirements of the permit.

B. The Contract Price shall include all material, labor and other permits and incidental costs related to:
   1. Preparing, updating and revising the Stormwater Construction Pollution Prevention Plan (SWPPP).
   2. Installing and maintaining all structural and non-structural items chosen by CONTRACTOR to comply with the construction SWPPP.
   3. Clean-up and disposal costs associated with clean-up and repair following storm events or CONTRACTOR caused spills on the Project.
   4. Implementing and maintaining Best Management Practices to comply with the OWNER'S stormwater code.
   5. Preparing the Notice of Intent and Notice of Termination shall be covered by the AZPDES General Permit for Arizona.
   6. Obtain and comply with DeMinimus permit, if such permit is required.

C. Coordinate the requirements under this Section with Section 02315, Excavation and Backfill, permit requirements. All necessary SWPPP controls and practices must be implemented prior to commencement of any construction activity.

1.2 SUBMITTALS

A. Submit, at least two days prior to the initial start of construction on the project; completed and signed Notice of Intent forms to the State of Arizona at the following addresses:
   1. Stormwater Program – Water Permits Section / NOI
      Arizona Department of Environmental Quality
      1110 West Washington, 5415B-3
      Phoenix, AZ 85007

B. Submit to the OWNER, no later than 14 calendar days before submitting to the State agency the following:
   1. Notice of Intent (NOI) to be covered by the AZPDES General Permit for Arizona, including certifications of signature.
   2. SWPPP for the Project, including certification of signature. Stormwater Plan shall include CONTRACTOR'S proposed temporary means for stormwater control during all phases of construction and include stormwater pumping/retention plans. This submittal shall be coordinated with CONTRACTOR'S Excavation Plan submittal, specified in Section 02315, Excavation and Backfill.
   3. A manual has been prepared by the Maricopa County Flood Control District to aid in CONTRACTOR'S preparation of the SWPPP. This manual, "Drainage Design Manual for Maricopa County Arizona, Volume III, Erosion Control" is available at the Flood Control District Office, 2801 West Durango Street, Phoenix, Arizona. The complete Construction General Permit is in the December 8, 1999, Federal Register available at local libraries and is also available from the ADEQ website at www.adeq.state.az.us/environ/water/permits/download/constgp.pdf.

C. Submit to the OWNER, as part of the Construction SWPPP a construction site inspection report that includes the following:
   1. Inspection scope.
   2. Inspector qualifications.
   3. Observations of SWPPP non-compliance and corrective steps taken.
   4. Certificate of Compliance with SWPPP and the AZPDES General Permit for Stormwater Discharge in the event of no incidents. Reports shall be submitted each quarter, at a minimum, throughout the Contract duration.

D. Submit to the OWNER, upon project completion the Notice of Termination (NOT) of coverage under AZPDES General Permit.

(The remainder of this page was left blank intentionally.)

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 01414

EARTHMOVING AND DUST CONTROL

PART 1 - GENERAL

1.1 DESCRIPTION

A. Obtain all earthmoving permits and any other permits required for earthmoving and dust generating operations related to the Work as required by the Maricopa County Air Pollution Control Regulations.

B. Not cause or allow any dust generating operation, earthmoving operation, use of property, or any other operation which causes fugitive dust emissions that exceed the 20 percent visible emission opacity limit in Rule 300 of Maricopa County's Air Pollution Control Regulations.

C. If requested by the OWNER, ENGINEER, or Maricopa County representative, shall conduct opacity observations for visible emissions of fugitive dust in accordance with techniques specified in USEPA Reference Method 9.

D. In addition to earthmoving permits, obtain an approved Dust Control Plan from Maricopa County. At a minimum, the Dust Control Plan shall include the following information:
   1. Name(s), address(es) and phone number(s) of the person(s) responsible for the preparation, submittal, and implementation of the Dust Control Plan and responsible for the dust generating operations.
   2. A site plan that describes the total area of land surface to be disturbed (in acres); the operations and activities to be performed on the site; actual and potential sources of fugitive dust emissions; and the delivery, transportation, and storage areas for the site (including types of materials stored and appropriate size of material stock piles).
   3. Description of the Reasonably Available Control Measures (RACM) to be applied during all periods of dust generating operations at all actual and potential sources of fugitive dust.
   4. Description of dust suppressants to be applied including product specifications; method, frequency, and intensity of application; type, number, and capacity of application equipment; and certifications related to the suppressant's appropriate and safe use.
   5. Description of specific surface treatment(s) or RACM used to control material track-out where unpaved or access points join paved surfaces.
   6. Description of at least one alternative RACM for each actual and potential fugitive dust source shall be designated as a contingency measure.

E. Post a copy of all earthmoving permits as well as the approved Dust Control Plan in a conspicuous location at the worksite and provide a copy of each to the ENGINEER.

F. Maintain a daily written log that records the actual application or implementation of the RACMS described in the approved Dust Control Plan. Maintain this written log and supporting documentation on site and shall make available for review on request by ENGINEER, OWNER, or Maricopa County representative. Retain copies of the Dust Control Plan, RACM implementation records, and all supporting documentations for a minimum of three years.

G. At a minimum, provide all necessary equipment and materials to apply sufficient dust suppressants (e.g., water, etc.), properly clean (sweep, etc.) all track-out areas, and provide adequate physical stabilizations (e.g., gravel, recycled asphalt, etc.) to meet all requirements of the earthmoving permit and approved Dust Control Plan. Use these methods to control fugitive dust generation from all CONTRACTOR operations on all CONTRACTOR areas including, but not limited to:
   1. Construction areas.
   2. Vehicle and equipment parking areas.
   3. Material storage areas.
   4. Office and trailer areas.
   5. Haul and access roadways.
   6. Track-out areas.
   7. All other areas where CONTRACTOR work, storing, or parking of vehicles, equipment, and materials.

H. Pay all fines issued to the OWNER by the USEPA, ADEQ, or Maricopa County due to violation of CONTRACTOR'S earthmoving permit and Dust Control Plan.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 01415

CONFINED SPACE ENTRY PLAN

PART 1 - GENERAL

1.1 DESCRIPTION

OWNER has determined that portions of the Work site may constitute "confined spaces" as defined in 29 CFR §1926.21(b)(2) and 1910.146. Accordingly, incorporate into its Safety Plan for the Work site appropriate measures to protect the health and safety of all persons on the Work site or who may be affected by the Work, including, without limitation thereby, employees and representatives of CONTRACTOR, any subcontractor, OWNER, or ENGINEER while they are present and engaged in the performance of their duties on the Work site.

Comply with all local, State and Federal rules and regulations related to the protection of persons working or entering into confined spaces including, but not limited to the following:

1. 29 United States Code §654.
2. Title 29 Code of Federal Regulations Parts 1910 and 1926, Occupational Safety and Health.
3. Ariz. Rev. Stat. §23-403.
4. City of Phoenix, Confined Space Program

To assure OWNER that CONTRACTOR is complying with the intent of the regulations stated in Paragraph 1.1.A, above, as they relate to the protection of all persons on the Work site, CONTRACTOR'S Safety Plan, at a minimum, respond to the following requirements as they relate to Work in confined spaces:

1. Conducting a Site-specific hazard assessment to identify confined spaces that should be characterized as "Permit Required Confined Spaces" within the meaning of 29 CFR §1926.21 (b)(6)(i) and 29 CFR §1910.146.
2. Adopting as an element of its Safety Plan appropriate requirements for safeguarding access to "Permit Required Confined Spaces".
3. Providing training, personal protective or safety equipment and personnel as needed to perform the Safety Plan's requirements for "Permit Required Confined Spaces."
4. Performing all record-keeping required for "Permit Required Confined Spaces", including the required permits and confined space data sheets located in Section 01331, Reference Forms.

1.2 CONFINED SPACES SAFETY PLAN REQUIREMENTS

A. For purposes of the Safety Plan requirements listed in Article 1.1, above, "confined spaces" are those areas on or about the Work site that fall within OSHA's definition

as "any space having limited means of egress, which is subject to the accumulation of toxic or flammable contaminants or has an oxygen deficient atmosphere. Confined or enclosed spaces include, but are not limited to, storage tanks, process vessels, bins, boilers, ventilation or exhaust ducts, sewers, underground utility vaults, tunnels, pipelines, and open top spaces more than four feet in depth such as pits, tubs, vaults, and vessels."

B. Ensure that those persons who are required to enter a confined space are trained according to OSHA requirements set forth in 29 CFR §1926.21 (b)(6)(i).

C. If the confined space is a "Permit Required Confined Space", then comply with the standards set forth in 29 CFR §1910.146. and the City of Phoenix, Confined Space Program.

D. "Permit Required Confined Space" means a confined space that has one or more of the following characteristics:
   1. Contains or has the potential to contain a hazardous atmosphere.
   2. Contains a material that has the potential for engulfing an entrant.
   3. Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or floors, or by a floor that slopes downward and tapers to a smaller cross-section.
   4. Contains any other recognized serious safety or health hazard.

1.3 SUBMITTALS

A. Prepare and submit a site-specific Confined Space Entry Plan as a portion of the CONTRACTOR'S site-specific Health and Safety Plan.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 01416

SPECIAL INSPECTIONS

PART 1 - GENERAL

1.1 DESCRIPTION

A. The following types of Work will be subject to Special Inspections, which will be completed by the special inspector employed by the OWNER or Project Representative designed by the OWNER:
   1. High-Strength Bolting: During all bolt installations and tightening operations.
      a. Exceptions:
         1) The special inspector need not be present during the entire installation and tightening operation, provided he has:
            a) Inspected the surfaces and bolt type for conformance to plans and specifications prior to start of bolting, and "will, upon completion of all bolting, verify the minimum specified bolt tension for ten percent of the bolts for each connection, with a minimum of two bolts per connection".
         2) In bearing-type connections when threads are not required by design to be excluded from the shear plane, inspection prior to or during installation will not be required.
   2. Concrete.
   3. Reinforcing Steel.
   4. Structural Welding.
   5. Structural masonry.
   6. Epoxy Anchors.
   7. Electrical Inspections.
   8. Polyvinyl chloride liner for concrete.
   9. Grounding inspections.
   10. Major equipment.

1.2 SPECIAL INSPECTOR

A. The special inspector shall be a qualified person who shall demonstrate his competence to the satisfaction of the regulatory authorities for inspection of the particular type of construction or operation requiring special inspection.

1.3 DUTIES AND RESPONSIBILITIES OF SPECIAL INSPECTOR

A. The special inspector shall observe the Work assigned to be certain it conforms to the Contract Documents.

B. The special inspector shall furnish inspection reports to the regulatory authorities, the ENGINEER and other designated persons. All discrepancies shall be brought to the immediate attention of CONTRACTOR for correction, then, if uncorrected, to the ENGINEER and regulatory authorities.

C. The special inspector shall submit a final signed report stating whether the Work requiring special inspection was, to the best of his knowledge, in conformance with the Contract Documents and the applicable workmanship provision of these codes.

1.4 PERIODIC SPECIAL INSPECTIONS

A. Some inspections may be made on a periodic basis and satisfy the requirements of continuous inspection, provided this periodic scheduled inspection is performed as outlined in the Contract Documents and approved by the regulatory authorities.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 01420

REFERENCES

PART 1 - GENERAL

1.1 DEFINITIONS

A. General: Definitions of basic Contract terms are included in the General Conditions.

B. Definitions of terms commonly found in the Specifications are as follows:
   1. Indicated: The term indicated refers to graphic representations, notes, or schedules on the Drawings, or to other paragraphs or schedules in the Specifications and similar locations in the other Contract Documents. Terms such as "shown", "noted", "scheduled", and "specified" are used to help the user locate the reference. There is no limitation on the location.
   2. Installer (or applicator, or erector): An installer is CONTRACTOR or another entity engaged by CONTRACTOR, either as an employee or subcontractor to perform a particular construction activity, including installation, erection, application or similar operations. Installers are required to be experienced in the operations they are engaged to perform.
      a. The term "experienced", when used with the term "installer", means having successfully completed a minimum of five previous projects similar in size and scope to this Project; being familiar with the special requirements indicated; and having complied with the requirements of authorities having jurisdiction and of the Supplier of the product being installed.
   3. Trades: Use of a term such as "carpentry" does not imply that certain construction activities must be performed by accredited or unionized individuals of a corresponding generic name, such as "carpenter". It also does not imply that requirements specified apply exclusively to trades persons of the corresponding generic name.
   4. Assigned Specialists: Certain Sections of the Specifications require that specific construction activities shall be performed by specialists who are recognized experts in those operations. Said specialists shall be engaged for those activities, and their engagement is a requirement over which CONTRACTOR has no option. These requirements shall not be interpreted to conflict with the enforcement of building codes and similar regulations governing the Work. Also, they are not intended to interfere with local trade-union jurisdictional settlements and similar conventions. Such assignments shall not relieve CONTRACTOR of its responsibility for fulfilling the requirements of the Contract Documents.
   5. Equipment Identification: Several terms define the information attached to equipment.

a. The term "CMMS Tag" means information attached to equipment pertaining to the City of Phoenix Water Services Department Computerized Maintenance Management System. CMMS Tags shall be provided by the CONTRACTOR. Refer to Section 01630, Equipment Identification Tag System for specifications regarding CMMS Tags.
b. The term "Manufacturer Nameplate" means information attached to equipment by the manufacturer pertaining to equipment criteria, such as capacity, power supply requirement, model number, etc.

1.2 ABBREVIATIONS

A. Common abbreviations, which may be found in the Specifications, are:

alternating current	AC
Ampere	A
ante meridiem	am
Average	avg.
biochemical oxygen demand	BOD
brake horsepower	BHP
British thermal unit	BTU
Centigrade	C
Company	Co.
cubic inch	cu. in.
cubic foot	cu. ft.
cubic yard	cu. yd.
cubic feet per minute	cfm
cubic feet per second	cfs
Decibel	DB
degree Centigrade (or Celsius) (Say)	20°C
degree Fahrenheit (Say)	68°F
Diameter	dia.
direct current	DC
Dollars	$
Each	ea
Efficiency	eff
Fahrenheit	F
feet per hour	fph

Feet	ft.
feet per minute	fpm
feet per second	fps
Figure	Fig.
Flange	flg
foot-pound	ft-lb
gallon	gal
gallons per minute	gpm
gallons per second	gps
gram	g
Hertz	Hz
horsepower	hp
hour	hr
inch	in.
inch-pound	in.-lb
inside diameter	id
kilovolt-ampere	kva
kilowatt	KW
kilowatt-hour	kwhr
linear foot	lin. ft.
liter	l
maximum	max.
mercury	Hg
milligram	mg
milligrams per liter	mg/l
milliliter	ml
millimeter	mm
million gallons per day	mgd
million gallon	mil
minimum	min.
National Pipe Threads	NPT
net positive suction head	npsh
number	No.
ounce	oz
outside diameter	OD

parts per million	ppm
post meridiem	pm
pound	lb
pounds per square inch	psi
pounds per square inch absolute	psia
pounds per square inch gage	psig
pounds per square foot	psf
revolutions per minute	rpm
second	sec.
specific gravity	sp gr
square	sq
square foot	sq ft
square inch	sq in
square yard	sq yd
standard	std
standard cubic feet per minute	scfm
total dynamic head	tdh
totally-enclosed-fan-cooled	tefc
volt	V

1.3 APPLICABLE CODES

A. When a reference standard is specified, comply with requirements and recommendations stated in that standard, except when they are modified by the Contract Documents, or when applicable laws, ordinances, rules, regulations or codes establish stricter standards. The latest provisions of applicable standards shall apply to the Work, unless otherwise specified. Reference standards include, but are not necessarily limited to, the following:
   1. American Association of State Highway and Transportation Officials (AASHTO).
   2. American Concrete Institute (ACI).
   3. American Gear Manufacturers Association (AGMA).
   4. American Institute of Steel Construction (AISC).
   5. American Iron and Steel Institute (AISI).
   6. American National Standards Institute (ANSI).
   7. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE).
   8. American Society of Mechanical Engineers (ASME).
   9. American Society for Testing and Materials (ASTM).
   10. American Water Works Association (AWWA).

11. American Welding Society (AWS).
12. Concrete Reinforcing Steel Institute (CRSI).
13. Factory Mutual (FM).
14. Institute of Electrical and Electronics Engineers (IEEE).
15. National Electrical Manufacturer's Association (NEMA).
16. National Electrical Code (NEC) current adoption.
17. City of Phoenix – Amendments to the National Electric Code.
18. Occupational Safety and Health Administration (OSHA).
19. National Fire Protection Association (NFPA).
20. Prestressed Concrete Institute (PCI).
21. Underwriters' Laboratories, Inc. (UL).
22. All other applicable standards listed in the Specifications and the standards of utility service companies, where applicable.
23. Maricopa Association of Governments (MAG), Uniform Standard Specifications for Public Works Construction, as supplemented by the City of Phoenix. References to MAG Standard Details refer to the "Uniform Standard Details for Public Works Construction" sponsored and distributed by the Maricopa Association of Governments 1999, Arizona.
24. International Building Code, with City of Phoenix Amendments.
25. National Electric Code – NFPA 70, with City of Phoenix Amendments.
26. American Petroleum Institute (API).
27. Uniform Building Code as supplemented by the City of Phoenix, Building Construction Code.
28. International Energy Conservation Code, with City of Phoenix Amendments.
29. Phoenix Fire Code.
30. International Fuel and Gas Code, with City of Phoenix Amendments.
31. International Mechanical Code, with City of Phoenix Amendments.
32. Uniform Plumbing Code, with City of Phoenix Amendments.
33. National Sanitation Foundation (NSF-61) and Arizona Administration Code (AAC # 18-4-213)
    a. Incorporate the requirements NSF-61, Drinking Water System Components Health Effects and AAC # 18-4-213, Standards for Additives, Materials and Equipment on all potable water systems, water treatment facilities and water distribution facilities.

B. To ensure consistent application of standards and codes the following terminology definitions shall be applicable throughout the contract documents.

TERM	DEFINITION
Phoenix Building Code	International Building Code with City of Phoenix Amendments
Phoenix Electrical Code	National Electric Code – NFPA 70 with City of Phoenix Amendments

Phoenix Energy Conservation Code	International Energy Conservation Code with City of Phoenix Amendments
Phoenix Fire Code	Phoenix Fire Code based on International Fire Code
Phoenix Fuel and Gas Code	International Fuel and Gas Code with City of Phoenix Amendments
Phoenix Mechanical Code	International Mechanical Code with City of Phoenix Amendments
Phoenix Plumbing Code	Uniform Plumbing Code with City of Phoenix Amendments
Phoenix Construction Code	All of the Codes Listed Above

1.4 OWNER'S REFERENCE SPECIFICATIONS

A. The Work, as may be otherwise specified, shall conform to the following Reference Specifications:
1. All specifications and codes indicated in part 1.3 of this section.

B. Maintain a complete copy of the Reference Specifications on the site.

1.5 INDUSTRY STANDARDS

A. Applicability of Standards: Except where the Contract Documents include more stringent requirements, applicable construction industry standards have the same force and effect as if bound or copied directly into the Contract Documents to the extent referenced. Such standards are made a part of the Contract Documents by reference.

B. Publication Dates: For applicable publication dates, refer to General Conditions.

C. Conflicting Requirements: Where compliance with two or more standards is specified and the standards establish different or conflicting requirements for minimum quantities or quality levels, refer to ENGINEER for a decision before proceeding.

D. Copies of Standards: Each entity engaged in construction on the Project is required to be familiar with industry standards applicable to its construction activity. Copies of applicable standards are not bound with the Contract Documents. Where standards are required to perform a required construction activity, obtain copies of same from the publication source.

E. Abbreviations and Names: Whenever in these Specifications or the other Contract Documents references are made to the standards, specifications, or other published data of international, national, regional or local organizations, such organizations may be referred to by their acronym or abbreviation only. The following acronyms or abbreviations, which may appear in the Specifications, shall have the meanings indicated herein.

1.	AA	Aluminium Association
2.	AABC	Associated Air Balance Council
3.	AAMA	American Architectural Manufacturers Association
4.	AASHTO	American Association of State Highway and Transportation Officials
5.	ACI	American Concrete Institute
6.	ACS	American Chemical Society
7.	AFBMA	Anti-Friction Bearing Manufacturers' Association
8.	AGMA	American Gear Manufacturers Association
9.	AI	Asphalt Institute
10.	AIChE	American Institute of Chemical Engineers
11.	AISC	American Institute of Steel Construction
12.	AISI	American Iron and Steel Institute
13.	AITC	American Institute of Timber Construction
14.	ALS	American Lumber Standards
15.	AMA	Acoustical Materials Association
16.	AMCA	Air Movement and Control Association
17.	ANSI	American National Standards Institute
18.	APA	American Plywood Association
19.	API	American Petroleum Institute
20.	APHA	American Public Health Association
21.	AREA	American Railway Engineering Association
22.	ARI	Air Conditioning and Refrigeration Institute
23.	ASA	American Standards Association
24.	ASAE	American Society of Agricultural Engineers

25.	ASTM	American Society for Testing and Materials
26.	ASCE	American Society of Civil Engineers
27.	ASHRAE	American Society of Heating, Refrigerating and Air Conditioning
28.	ASME	American Society of Mechanical Engineers
29.	AWI	Architectural Woodwork Institute
30.	AWPA	American Wood Preservers' Association
31.	AWPB	American Wood Preservers Bureau
32.	AWPI	American Wood Preservers' Institute
33.	AWS	American Welding Society
34.	AWWA	American Water Works Associations
35.	BHMA	Builders Hardware Manufacturers' Association
36.	CBMA	Certified Ballast Manufacturers' Association
37.	CDA	Copper Development Association
38.	CGA	Compressed Gas Association
39.	CISPI	Cast Iron Soil Pipe Institute
40.	CMAA	Crane Manufacturers' Association of America
41.	CRSI	Concrete Reinforcing Steel Institute
42.	EPA	Environmental Protection Agency
43.	ETL	Engineering Test Laboratories
44.	FCC	Federal Communications Commission
45.	FEMA	Federal Emergency Management Agency
46.	FGMA	Flat Glass Marketing Association
47.	FM	Factory Mutual Association
48.	FS	Federal Specification
49.	GA	Gypsum Association
50.	HEW	Department of Health, Education and Welfare
51.	HI	Hydraulic Institute
52.	HMI	Hoist Manufacturers' Institute
53.	HUD	Department of Housing and Urban Development

54.	ICBO	International Conference of Building Officials
55.	ICEA	Insulated Cable Engineers' Association
56.	IEEE	Institute of Electrical and Electronic Engineers
57.	IES	Illuminating Engineering Society
58.	IFI	Industrial Fasteners Institute
59.	IRI	Industrial Risk Insurers
60.	ISA	The Instrumentation Systems and Automation Society
61.	ISO	Insurance Services Office
62.	MAG	Maricopa Association of Governments
63.	MIA	Marble Institute of America
64.	MS	Military Specifications
65.	MMA	Monorail Manufacturers' Association
66.	NAAMM	National Association of Architectural Metal Manufacturers
67.	NACE	National Association of Corrosion Engineers
68.	NARUC	National Association of Railroad and Utilities Commissioners
69.	NBHA	National Builders Hardware Association
70.	NEC	National Electrical Code
71.	NEMA	National Electrical Manufacturers Association
72.	NESC	National Electrical Safety Code
73.	NFPA	National Fire Protection Association
74.	NHLA	National Hardwood Lumber Association
75.	NHPMA	Northern Hardwood and Pine Manufacturer's Association
76.	NLMA	National Lumber Manufacturers' Association
77.	NRCA	National Roofing Contractors Association
78.	NSF	National Sanitation Foundation
79.	NTMA	National Terrazzo and Mosaic Association
80.	NWWDA	National Wood Window and Door Association
81.	OECI	Overhead Electrical Crane Institute
82.	OSHA	Occupational Safety and Health Administration

83.	PCI	Precast Concrete Institute
84.	PEI	Porcelain Enamel Institute
85.	PPI	Plastic Pipe Institute
86.	PS	Product Standards Section-U.S. Department of Commerce
87.	RMA	Rubber Manufacturers' Association
88.	SAE	Society of Automotive Engineers
89.	SCPRF	Structural Clay Products Research Foundation
90.	SDI	Steel Deck Institute
91.	SDI	Steel Door Institute
92.	SIGMA	Sealed Insulating Glass Manufacturing Association
93.	SJI	Steel Joist Institute
94.	SMACNA	Sheet Metal and Air Conditioning National Association
95.	SPI	Society of the Plastics Industry
96.	SSPC	The Society for Protective Coatings
97.	SWI	Steel Window Institute
98.	TEMA	Tubular Exchanger Manufacturers' Association
99.	TCA	Tile Council of America
100.	UL	Underwriters' Laboratories, Inc.
101.	USGS	United States Geological Survey
102.	USPHS	United States Public Health Service
103.	WCLIB	West Coast Lumber Inspection Bureau
104.	WWEMA	Water and Wastewater Equipment Manufacturers Association
105.	WWPA	Western Wood Products Association

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 01453

TESTING OF HYDRAULIC STRUCTURES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, material, tools, equipment and incidentals as shown, specified and required to clean, flush and test structures.
   2. The Work also shall include all labor and materials required to prepare a structure for testing, convey water to the testing location, perform the testing, and all labor and materials required to drain and dispose of water used for testing.

B. Hydraulic Structures Scheduled for Hydrostatic Testing: Clean and test the following structures:

Hydraulic Structure Description	Service
1. Biofilter Concrete Tank	Contains and drain irrigation water as part of biofilter operation.
2. Lift Station No. 66 Wet Well	Contains sanitary sewer as well as submersible pumps.

C. Water for Testing:
   1. Water for initial testing will be furnished by the OWNER.
   2. Provide all temporary piping, hose, valves, backflow preventors, appurtenances, and services required for testing.
   3. Convey the water to the testing location.
   4. Water for testing may be withdrawn from:
      a. Onsite non-potable water (NPW).
   5. The maximum rate at which water may be withdrawn is 25gpm. Provide on the withdrawal piping, downstream of the backflow preventor, a valve to control the rate of flow and a flow meter. The flow meter shall be calibrated within one year and field calibrated/verified prior to the date of its use, and its certification of calibration shall be submitted to the ENGINEER for approval.
   6. Cost of water for re-testing shall be paid by CONTRACTOR to OWNER at OWNER'S standard rates.

D. Testing and piping is specified under Section 15051, Buried Piping Installation, and Section 15052, Exposed Piping Installation.

1.2 DEFINITIONS

A. The term “hydraulic structures” is defined as tanks, channels, and other structures through which liquid is conveyed or that hold liquid. Hydraulic structures include structures that are open to the atmosphere and structures with closed tops. Hydraulic structures, include but are not limited to, wet wells, junction chambers equalization tanks, storage tanks, treatment process tanks such as grit chambers, clarifiers, aeration tanks, filter beds, contact tanks, and other channels or tanks as designated herein.
   1. Excluded are structures where cleaning and testing are specified under other Sections or contracts.

1.3 SUBMITTALS

A. Provide written notice of the proposed testing schedule for a given structure for review by the ENGINEER and OWNER at least 14 calendar days prior to the scheduled testing. Include proposed plans for water conveyance, control, and disposal. Testing will not commence without approval of ENGINEER.

B. Shop Drawings: Submit for approval the following:
   1. Cleaning procedures.
   2. Hydrostatic testing procedures, methods, equipment, coordination, and schedules.
   3. Report for each test.

PART 2 – PRODUCTS

2.1 MATERIALS

A. Temporary valves, bulkheads, and other water control equipment and materials shall be determined by CONTRACTOR subject to the ENGINEER'S review. No materials shall be used which would be injurious to the construction or its future function.

PART 3 – EXECUTION

3.1 CLEANING

A. Cleaning Requirements:
   1. Remove all scaffolding, planks, tools, rags, dirt, debris, and material not part of the structure prior to testing.
   2. Thoroughly clean the walls, floors, and operating equipment by sweeping, high-pressure wash, scrubbing, or other methods approved by ENGINEER.
   3. Remove all water, dirt, or foreign material accumulated during cleaning from the hydraulic structure. Provide temporary pumps, piping, and facilities as

required to discharge water from the cleaning operation in a manner approved by ENGINEER.

4. Do not proceed with testing until ENGINEER has approved the results of the cleaning operation.
5. Cleaning shall conform to the requirements of Section 01740, Cleaning.

3.2 GENERAL FOR TESTING AND DISINFECTION

A. The following requirements apply:
   1. Each hydraulic structure shall be tested separately.

B. Hydraulic structures shall be free of visible leakage. Repair leaks in a manner subject to ENGINEER'S approval and in accordance with the Contract Documents.

C. The structure shall be tested prior to the application of exterior coating systems and the installation of masonry block veneer, if applicable.

D. Release of water from structures, after testing shall be as approved by the ENGINEER.

3.3 HYDROSTATIC TESTING OF HYDRAULIC STRUCTURES

A. Analysis of data from hydrostatic tests of hydraulic structures shall be performed by CONTRACTOR in accordance with the requirements of ACI 350.1 and as specified herein. Supply all materials and labor to obtain the test data.

B. Prior to the start of hydrostatic testing, the following shall be met.
   1. All elements of the structure that will resist pressure exerted by the retained liquid shall be in place and at specified strength levels. Concrete shall be fully cured.
   2. Structure walls shall not be backfilled and, if damp proofing is specified, coated with damp proofing prior to leakage testing, unless otherwise approved by ENGINEER.
   3. All valves, gates, blind flanges, and other items, other than concrete, that control the flow of or otherwise retain the liquid contents of the structure, shall be checked for water-tightness. If not watertight, provide measures to ensure water-tightness during the hydrostatic test.
   4. Defective concrete shall be repaired.
   5. Notify ENGINEER and OWNER a minimum of 48 hours prior to the start of filling of the structure for hydrostatic testing.
   6. Concrete hydraulic structures shall remain filled with clean water for an initial 48-hour period to allow for adsorption. Following this initial period, add make-up water to fill the hydraulic structure to the specified water surface test elevation.

C. Fill the hydraulic structure with clean water to the maximum water surface test elevation specified. Where no test elevation is specified and fluid level in the structure will normally be controlled by a weir, fill the structure to an elevation 6-inches below the weir crest. Where no test elevation is indicated and the structure does not have a flow control weir, the test elevation shall be two feet below the top of the structure.

Hydraulic Structure Description	Hydraulic Structure Service	Water Surface Elevation for Testing
1. Biofilter Concrete Tank	Contains and drain irrigation water as part of biofilter operation.	1542.0
2. Lift Station No. 66 Wet Well	Contains sanitary sewer as well as submersible pumps.	1543.0

D. Filling Hydraulic Structures with Water:
1. Fill the portion of the hydraulic structure to be tested at a rate not to exceed two vertical feet per hour.
2. During filling, provide a backflow preventor at the point where water is withdrawn from the existing potable water system, if applicable.

E. After water has been brought to the test elevation and the specified wetting period has elapsed, inspect the exposed surfaces of the structure for leakage. Repair locations where leakage or weeping is evident prior to the start of hydrostatic testing.

F. Hydrostatic test duration shall be determined by the ENGINEER based on ACI 350.1, but shall not be less than 24 hours.

G. Allowable Leakage:
1. Leakage is defined as the quantity of water that must be supplied to the hydraulic structure or any section thereof to maintain the water level within 3-inches of the specified water surface test elevation during the hydrostatic test, plus the amount of water required to fill the hydraulic structure to the specified water surface test elevation at the conclusion of the hydrostatic test, plus precipitation, minus an allowance for evaporation if applicable.
2. For concrete structures without lining of interior wetted surfaces, the allowable leakage is 0.075 percent of the volume tested per 24-hour period.
3. For concrete structures with interior wetted surfaces lined with a waterproof material, the allowable leakage is 0.050 percent of the volume tested per 24-hour period.

H. Measurement Locations:
   1. Structures or structure cells that are less than 1,000 square feet in water surface area shall have measurements of water level taken at a minimum of two locations that are approximately 180 degrees apart.
   2. Structures or structure cells that are greater than 1,000 square feet in water surface area shall have measurements of water level taken at a minimum of four locations that are approximately 90 degrees apart.
   3. Each measurement location shall be marked and given a reference number. A reference point shall be marked on the face of the wall above the test water surface in a manner that will prevent movement or deterioration of the reference point mark during the test.
   4. Measurement locations shall be located so that the effects of wave action and wind are minimized.

I. Evaporation and Precipitation Measurement:
   1. In hydraulic structures that are open to the atmosphere, a clear plastic calibrated open-topped container not less than 18-inches in diameter and depth shall be partially filled, floated in the tank, and held in position near each measurement location. Calibration increments shall be 0.1-inch or less.
   2. Containers shall be located so that they are not shaded by the structure's walls, and are away from overhead items such as beams, pipes, and walkways.

J. Test Measurements:
   1. Do not start hydrostatic tests when severe weather conditions, such as heavy precipitation, high winds, major changes in average daily temperature, and other severe conditions are predicted.
   2. Record the following measurements at each test location at the start of the test period and at 12-hour intervals thereafter.
      a. Distance from reference point to test water surface.
      b. Depth of water in the evaporation-precipitation containers.
      c. Temperature of the test water at a point 18-inches below the water surface.
      d. Temperature of the water in the evaporation-precipitation containers at mid-depth.
   3. If the water surface is subject to wave action at the measurement location, the average water surface elevation of the wave oscillations shall be recorded as the data.
   4. The change in the water surface elevation at each measurement location shall be averaged and adjusted as follows:
      a. The total change in the hydraulic structure's water surface elevation shall be adjusted by the average change in water surface elevation in the evaporation-precipitation containers.
      b. Where the averaged water temperature measurements vary by more than 3 degrees from start to completion of the test period, adjustment in the test volume shall be determined by the change of the density of water resulting from the change in the average water temperature.

5. Determination of Leakage:
    a. Provide a test container filled with a known quantity of water at the start of the test. Attach the test pump suction to the test container.
    b. Pump water from the test container into the hydraulic structure with the test pump to maintain the water level in the hydraulic structure within 3-inches of the specified test elevation for the duration of the test period.
    c. At the conclusion of the test, pump water from the container into the hydraulic structure to attain the specified test elevation.
    d. Measure the water remaining in the container and record the amount used during the test on the test report.

K. Criteria for Acceptance:
1. The hydrostatic test will pass if the measured leakage is less than the allowable leakage and no leaks or weeping are observed.
2. The hydrostatic test shall be considered to have failed if the allowable leakage is exceeded or if leakage or weeping is observed.
3. If the test becomes unreliable due to excessive precipitation or other external factors, the test shall be re-started.
4. If a hydrostatic test fails, the structure may be re-tested immediately without repairs if approved by the ENGINEER. If the subsequent hydrostatic test fails, repair probable areas of leakage and repeat the hydrostatic test.
5. Re-test the structure until it meets the specified criteria for acceptance. Repair probable leakage areas before testing.

L. Reuse and Disposal of Water Used in Hydrostatic Tests:
1. Obtain written approval of the ENGINEER before water used in one hydrostatic test is pumped to a different hydraulic structure for reuse in a subsequent test.

M. The hydraulic structure shall not be backfilled or damp-proofed until acceptance of the hydrostatic test by the ENGINEER.

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3.4 TESTING OF APPURTENANT PIPING

A. Piping appurtenant to hydraulic structures shall be tested as specified in applicable Sections.

+ + END OF SECTION + +

SECTION 01510

TEMPORARY CONSTRUCTION FACILITIES

PART 1 - GENERAL

1.1 GENERAL

A. Responsible for all temporary construction facilities required for the Work. Make all arrangements with utility service companies for temporary services and shall pay all costs associated therewith.

B. Temporary construction facilities include:
   1. Water.
   2. Electricity and Lighting.
   3. Telephone.
   4. Heat, Weather Protection and Ventilation.
   5. Fire Protection.
   6. Sanitary and First Aid Facilities.

C. Abide by all rules and regulations of the utility service company or authority having jurisdiction.

D. Sufficient temporary heat and ventilation shall be provided to assure safe working conditions and that no damage will occur to any of the Work. In addition, all enclosed areas shall be maintained at a minimum of 50° F, unless otherwise specifically accepted in the Specifications.

E. Provide all materials, equipment and power required for temporary electricity and lighting. Include continuous power for construction site offices. Provide all outlets with circuit breaker protection and comply with ground fault protection requirements of NEC. Minimum lighting shall be five-foot candles for open areas, ten-foot candles for stairs and shops. Provide minimum of one 30- watt lamp each 20 feet in Work areas.

F. Suitably enclosed chemical or self-contained toilets shall be provided for the use of general employees. Toilets shall be located near the Work site and secluded from observation insofar as possible. Toilets shall be serviced at regular intervals, kept clean and supplied throughout the course of the Work.

G. Furnish and maintain a safe drinking water supply readily available to all workers.

H. Responsible for all utility service costs until Final Acceptance of the Work. Included are all fuel, power, light, heat and other utility services necessary for execution, completion, testing and initial operation of the Work.

I. CONTRACTOR:
   1. Comply with applicable requirements specified in Division 15, Mechanical, and Division 16, Electrical.
   2. Maintain and operate systems to assure continuous service.
   3. Modify and extend systems as Work progress requires.
   4. Completely remove temporary materials and equipment when their use is no longer required.
   5. Clean and repair damage caused by temporary installations or use of temporary facilities.
   6. Restore existing facilities used for temporary services to specified or to original condition.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 01511

TEMPORARY ELECTRICITY

PART 1 - GENERAL

1.1 DESCRIPTION

A. Temporary electrical service shall be provided by CONTRACTOR until Final Acceptance of the Work, unless otherwise agreed by ENGINEER.

B. All costs, including the charge for power consumed, shall be assumed by CONTRACTOR. Also, provide power for testing, initial start-up and commissioning of equipment.

C. The temporary service shall conform to applicable provisions of Division 16, Electrical.

D. Materials and equipment may be new or used; however, they shall be in first class, fully serviceable condition and shall not create unsafe conditions or violate requirements of applicable codes.

E. Service is required for lighting, power tools, construction trailers, dewatering equipment, and similar usages. Electric space heaters and large welding machines are not included herein.

F. All temporary service required beyond the specified locations shall be the responsibility of CONTRACTOR requiring such power, who shall furnish his own portable generator or other means.

1.2 POWER SOURCE AND SERVICE REQUIRED

A. A temporary power service is available from one of the following locations:
   1. Existing 2-pole 480A, 120/240V circuit breaker in existing panelboard LP-A (Ckt 1,3).
   2. New 2-pole 120/240V circuit breaker in existing panelboard LP-A (Ckt 39,41).

B. Temporary power shall be 240/120 volt, single phase, 60 Hz with sufficient capacity to provide service for construction use by all trades and with the following minimum facilities:
   1. Local disconnect as well as frame and suitably sized trip primary circuit breaker.
   2. Two pole safety switch, and a 240/120 volt, single phase, 3 wire distribution panel.

C. Service shall be provided and maintained so that power can be secured at any desired point with no more than a 50-foot extension.

D. One power center, minimum, shall be provided on each floor.

E. Provide each outlet with circuit breaker protection and comply with ground fault protective requirements of NEC.

F. Work hours are specified under the General Conditions.

G. Provide continuous power for construction site offices.

H. Provide power to maintain continuous operation of existing facilities during changeover of electrical equipment.

I. Provide power for testing, checking, initial start-up of equipment and commissioning.

1.3 INSTALLATION

A. Install temporary work in a neat orderly manner and make structurally and electrically sound throughout.

B. Maintain installation throughout construction period to provide continuous service and to provide safe working conditions.

C. Modify service and rearrange wiring as Work progress requires.

D. Locate all facilities to avoid interference with hoisting, materials handling, storage, traffic areas, existing operable facilities and Work under other contracts.

E. Assume responsibility for and return to original condition any part of the permanent electrical system that is used for construction purposes.

1.4 REMOVAL

A. Completely remove temporary materials and equipment after permanent installation is in use.

B. Repair damage caused by the temporary service or its removal and restore to specified or original condition.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 01512

TEMPORARY LIGHTING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Temporary lighting shall be provided by CONTRACTOR.

1.2 DEFINITIONS

A. Work Lighting: That required to provide adequate illumination for Work being performed.

B. Safety Lighting: That required to provide:
   1. Adequate illumination for safe movement of authorized persons throughout project.
   2. Adequate illumination for public safety.
   3. Special warning lighting for hazardous conditions.

C. Security Lighting: That required in protection of Work from unauthorized entry.

1.3 DESCRIPTION OF SYSTEM

A. Furnish and install temporary lighting that is required for:
   1. Construction needs.
   2. Safe and adequate working conditions throughout the Work.
   3. Public safety.
   4. Security lighting.
   5. Lighting for temporary office, storage and construction buildings.

B. Lighting Intervals:
   1. Work Lighting:
      a. General: Five foot candles.
      b. All stairs: Ten foot candles.
      c. Construction Plant and Shops: Ten foot candles.
      d. For Detail and Finishing Work: Twenty foot candles.
      e. For Detailed Testing and Inspection: Thirty foot candles.
      f. For First Aid Stations: Thirty foot candles.
      g. Operating areas: One 300 watt lamp per 15 foot on centers.
   2. Safety Lighting:
      a. General: Five foot candles, minimum.
      b. For Hazardous Conditions: As required by applicable codes.
   3. Night Security Lighting: Provide over area within 50 feet of any portion of construction

C. Periods of Service:
   1. Work Lighting: Continuous from 15 minutes prior to 15 minutes past scheduled Work hours on scheduled Work days.
   2. Safety Lighting:
      a. Within Project site: At all times authorized personnel are present.
      b. Public areas: At all times.
   3. Security Lighting: All hours of darkness.

D. Maintain strict supervision of use of temporary lighting. Enforce conformance with applicable standards and safe practices and prevent abuse of services.

1.4 POWER

A. As specified in Section 01511, Temporary Electricity.

1.5 COSTS OF INSTALLATION AND OPERATION

A. Electrical contractor shall pay costs of Temporary Lighting, including costs of installation, maintenance and removal.

B. Power Costs: As specified in Section 01511, Temporary Electricity.

1.6 REQUIREMENTS OF REGULATORY AGENCIES

A. Comply with National Electrical Code (NEC) current adoption, and City of Phoenix – Amendments to the National Electrical Code.

1.7 USE OF OWNER'S EXISTING SYSTEM

A. Existing systems cannot be used for temporary lighting.

1.8 USE OF PERMANENT SYSTEM

A. Secure OWNER'S written permission for use of system, indicating conditions of use.

B. Furnish and install temporary lamps for temporary lighting.

C. Lamps used shall be replaced upon Final Acceptance of the Work

1.9 MATERIALS

A. Comply with applicable provisions of Division 16, Electrical.

B. Materials and equipment may be new or used, but must be adequate for purposes intended and must not create unsafe conditions or violate requirements of applicable codes.

C. Provide all required facilities, including wiring, switches, accessories and supports.

D. At CONTRACTOR'S option, patented specialty products may be used, if UL approved.

1.10 RECEPTACLES, FIXTURES

A. Standard products, meeting UL requirements.

B. Provide heavy-duty guards on fixtures.

C. Provide appropriate types of fixtures for environment in which used, in accordance with NEC and NEMA standards.

1.11 INSTALLATION

A. Install temporary work in neat and orderly manner and make structurally and electrically sound throughout.

B. Maintain throughout construction period to give continuous service and to provide safe working conditions.

C. Modify and extend lighting as Work progress requires.

D. Locate to avoid interference with or hazards to:
1. Work or movement of personnel.
2. Traffic areas.
3. Materials handling.
4. Storage areas.
5. Work for other contracts.

E. Install lighting switches at entrance to each area, or successive areas, so that progress to all areas of the Work may be made through lighted areas.

F. Install exterior security lighting.
1. Illuminate entire Work site.
2. Control lighting by photo-electric cell.

1.12 REMOVAL

A. Completely remove temporary materials and equipment after permanent lighting is in use.

B. Repair damage caused by temporary service and restore surfaces to specified, or original condition.

C. Immediately prior to completion of the Work, remove temporary lamps and install new lamps throughout.

PART 2 - PRODUCTS (NOT USED)

PART 3 -EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 01513

TEMPORARY HEAT, VENTILATION AND ENCLOSURE

PART 1 - GENERAL

1.1 DESCRIPTION

A. Temporary Enclosure: Sufficient preliminary enclosure of a portion of a structure, or of an entire building, to prevent entrance or infiltration of rainwater, wind or other elements, and to prevent undue heat loss from within the enclosed area.

B. Permanent Enclosure: State of construction at which all moisture and weather-protection elements of construction have been installed, in accordance with Contract Documents, either for a portion of structure, or for entire building.

1.2 DESCRIPTION OF SYSTEM

A. Provide temporary heat and ventilation in enclosed areas throughout construction period required to:
   1. Facilitate progress of Work.
   2. Protect Work and all products from rain, dampness and cold.
   3. Prevent moisture condensation on surfaces.
   4. Raise temperature of ground or materials for proper execution of Work.
   5. Provide suitable ambient temperatures and humidity levels for installations and curing of materials.
   6. Provide adequate ventilation to meet health regulations for safe working environment.
   7. Allow beneficial occupancy of Work, or portion of Work, prior to Final Acceptance, including air conditioning, if applicable.

B. Temperature Required:
   1. Except where specified otherwise, the limits of the temperatures, which shall be maintained during the time of temporary heating, are a minimum of 50°F to a maximum of the design temperature of the facility.
   2. During a normal working day, minimum temporary heat for the types of activities indicated shall be as follows:
      a. Placing, setting and curing of concrete and the erection of masonry units: 50°F.
      b. Application of masonry units: 55°F.
      c. Ten days prior to, during and until completion of the placing of interior woodwork and interior finishes such as varnishing and painting: 70°F.
      d. After application of interior finishes and until Final Acceptance of the Work: 70°F.

3. Twenty-four hours per day during placing, setting and curing of cementitious materials: As required by Specification Section for each product.
4. Storage Areas: As required by Specification Section for each product.
5. Provide temporary enclosures as required to maintain conditions described above.

C. Ventilation Required:
   1. General: Prevent hazardous accumulations of dusts, fumes, mists, vapors or gases in areas occupied during construction.
      a. Provide local exhaust ventilation to prevent harmful dispersion of hazardous substances into atmosphere of occupied areas.
      b. Dispose of exhaust in a manner that shall not result in harmful exposure to persons.
      c. Ventilate storage spaces containing hazardous or volatile materials.
   2. Provide adequate ventilation for:
      a. Curing installed materials.
      b. Humidity dispersion as needed to provide suitable ambient conditions for Work.

D. Maintain strict supervision of operation of temporary heating and ventilating equipment:
   1. Enforce conformance with all applicable codes and standards.
   2. Enforce safe practices.
   3. Prevent abuse of services.
   4. Prevent damage to finishes.
   5. Ensure that temporary facilities and equipment do not interrupt the continuous progress of construction operations.

1.3 COSTS OF INSTALLATION AND OPERATION

A. Pay all costs for temporary heat, ventilation and enclosures required during construction, including cost of installation, fuel, electricity, operation, maintenance and removal.

1.4 REQUIREMENTS OF REGULATORY AGENCIES

A. Obtain and pay for any permits as required by governing authorities.

B. Comply with federal, state and local laws, ordinances, rules and regulations and with utility service company regulations.

1.5 USE OF OWNER'S EXISTING SYSTEM

A. When the Work is an addition to an existing building, the existing systems in building may not be used for temporary heat and ventilation, unless the OWNER'S written permission can be secured and equitable allocation of costs acceptable to the OWNER is agreed upon.

1.6 USE OF PERMANENT SYSTEM

A. When completed, the permanent heating system may be used to provide temporary heat, if the system is substantially complete, and if the OWNER'S written permission for use of the system is obtained.

B. The following are the conditions for using the permanent heating system:
   1. Building must be sufficiently complete so it can fulfill the requirements as a "Permanent Enclosure."
   2. The permanent system shall be substantially complete including the installation and functionability of the systems' operating and safety controls. All heating equipment, piping systems, strainers, filters and associated items should be flushed, cleaned and prepared for proper operation.
   3. ENGINEER shall approve the time when the permanent system may be operated.

1.7 MATERIALS AND EQUIPMENT

A. Materials may be new or used, but shall be adequate for purposes intended and shall not create unsafe conditions nor violate requirements of applicable codes.

B. Provide all required facilities, including piping, wiring and controls.

C. Portable units shall be space heaters that burn natural gas or propane. They shall be units that meet code requirements and have the following:
   1. Safety controls against explosion, overheating and carbon monoxide buildup.
   2. Except where otherwise permitted by applicable codes, vent direct-fired units to outside.
   3. Adequate combustion air.

D. Electrical heaters for temporary heat shall not be used.

E. Provide covers or temporary enclosures to protect Work and materials.

1.8 INSTALLATION

A. Install all temporary Work in neat, orderly manner and make structurally, mechanically and electrically sound throughout.

B. Maintain to provide safe, continuous service at required times and to provide safe working conditions.

C. Modify and extend system as Work progress requires.

D. Locate units to provide uniform distribution of heat and air movement. When feasible, temporary units shall be located as near as possible to permanent piping.

E. If air conditioning or ventilating duct systems are to be used for drying purposes, provide and maintain temporary filters until permanent filters are installed.

F. Permanently installed direct radiation units, such as convectors or finned pipes, shall be protected with temporary sheet metal enclosures.

G. Locate all systems so as to avoid interference with or hazards to:
   1. Work or movement of personnel.
   2. Traffic areas.
   3. Materials handling.
   4. Storage areas.
   5. Finishes.
   6. Work of utility service companies.

1.9 REMOVAL

A. Completely remove temporary materials and equipment upon completion of construction.

B. Clean and repair damage caused by temporary installation, and restore all materials and equipment to specified or to original condition.

C. If permanent HVAC facilities were used for temporary heat, install new replaceable type filters or clean permanent filters

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 01514

TEMPORARY WATER

PART 1 - GENERAL

1.1 DESCRIPTION

A. Temporary water shall be provided by CONTRACTOR, as specified in the paragraphs below.

1.2 DESCRIPTION OF SYSTEM

A. Furnish and install temporary water service for entire Project for use throughout construction period.

B. Provide water hoses from hose bibbs to point of operations.

C. Also, provide water for sanitary facilities, first aid facilities, fire protection, field offices, cleaning, disinfection and testing.

D. Maintain adequate volume of water for all purposes.

E. Potable Water Source:
   1. Supplier: Provide water source by connecting to existing utility mains at locations designated by OWNER. Provide backflow preventers, where required. Hydrants cannot be taken out of service.
   2. Provide minimum 3/4-inch supply service and supply and install meter satisfactory to water utility.
   3. Permission shall be obtained from OWNER for water from hydrants.

F. Maintain strict supervision of use of temporary services:
   1. Enforce conformance with applicable codes and standards.
   2. Enforce sanitary practices.
   3. Prevent abuse of services.
   4. Prevent wasteful use of water.
   5. Protect system from freezing.

1.3 COSTS OF INSTALLATION AND OPERATION

A. Pay costs of temporary water service, including costs of installation, maintenance and removal of pipe and equipment.

B. Pay costs for water used by all trades.

1.4 REQUIREMENTS OF REGULATORY AGENCIES

A. Obtain and pay for permits, fees, deposits required by governing authorities.

B. Obtain and pay for temporary easements required across property, other than that of OWNER.

C. Comply with federal, state and local laws, ordinances, rules and regulations and standards, and with utility service company regulations.

1.5 USE OF OWNER'S EXISTING SYSTEM

A. Use existing system for temporary water for construction.

B. Modify and extend system as necessary to meet temporary water requirements.

C. Upon completion of Work, restore existing system to specified, or original condition.

1.6 MATERIALS

A. Comply with applicable provisions of Division 15, Mechanical.

B. Materials may be new or used, but must be adequate for purpose required, sanitary, and must not violate requirements of applicable codes.

C. Provide all required facilities, including piping, valves, pumps, pressure regulators, tanks and other appurtenances.

1.7 INSTALLATION

A. Install Work in a neat and orderly manner and make structurally and mechanically sound throughout.

B. Maintain to provide continuous service.

C. Modify and extend service as Work progress requires.

D. Locate piping and outlets to provide service convenient to work stations and to avoid interference with traffic and work areas, materials handling equipment, storage area, and work under other contracts.

E. Do not run piping on floor or on ground.

F. Provide drip pan under each hose bibb located within building, and connect drain to sewer.

G. Provide insulation, or other means, to prevent pipes from freezing.

H. When necessary to maintain pressure, provide temporary pumps, tanks and compressors.

I. Disinfect temporary or permanent potable water piping prior to use in accordance with City, State and Maricopa Association of Governments (MAG) requirements and as supplemented by the City of Phoenix.

1.8 REMOVAL

A. Completely remove temporary materials and equipment upon completion of construction.

B. Clean, repair damage caused by installation, and restore to specified or original condition.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 01515

TEMPORARY SANITARY AND FIRST AID FACILITIES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Temporary sanitary and first aid facilities shall be provided by CONTRACTOR.

B. Provide temporary sanitary and first aid facilities for use throughout the Contract including:
   1. Potable water and sanitary drinking cups.
   2. Sanitary drinking fountains, where feasible.
   3. Enclosed toilet facilities.
   4. Suitable general employee washing facilities.
   5. First aid stations at or immediately adjacent to all major Work areas and in the temporary field offices.
   6. Post telephone numbers of physicians, hospitals and ambulance services by each telephone at the Project site.
   7. At least one person thoroughly trained in first aid procedures shall be present on the site, whenever Work is in progress. These persons must have a certificate indicating that they have completed a first aid training course conducted by the American Red Cross or other approved agency. Submit the certificates to the ENGINEER.

C. Provide facilities and fixtures in compliance with all applicable federal, state, and local laws, ordinances, standards, and regulations.

D. Maintain strict supervision of use of facilities.

E. Maintain, service and clean facilities and keep them supplied continuously with soap, towels, paper and all other required supplies.

F. Enforce proper use of sanitary facilities, including preventing the committing of nuisances in buildings on the site.

G. Dispose of all wastes in conformance with applicable regulations.

1.2 COSTS OF INSTALLATION AND OPERATION

A. Pay all cost including installation, maintenance and removal.

1.3 USE OF EXISTING SYSTEM

A. Existing facilities may not be used, unless an agreement is obtained in writing from the OWNER stating the conditions of use.

1.4 USE OF PERMANENT FACILITIES

A. Permanent facilities shall not be used by construction personnel.

1.5 INSTALLATION AND REMOVAL

A. Temporary flush toilets or portable toilets may be used.

B. Comply with all applicable provisions of Division 15, Mechanical.

C. Completely remove temporary materials and equipment upon completion of construction and restore all damaged facilities to original condition.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 01516

TEMPORARY FIRE PROTECTION

PART 1 - GENERAL

1.1 DESCRIPTION

A. Conform to the fire protection and prevention requirements specified herein as well as those which may be established by federal, state or local governmental agencies.

B. Comply with all applicable provisions of NFPA Standard No. 241, Safeguarding Building Construction and Demolition Operations.

C. Facilities specified herein shall be provided by CONTRACTOR, but all other contractors shall conform to the provisions of this Section and all applicable laws, ordinances, rules and regulations.

1.2 REQUIRED FIRE FIGHTING EQUIPMENT

A. Provide portable fire extinguishers, rated not less than 2A or 5B in accordance with NFPA Standard No. 10, Portable Fire Extinguishers, for each temporary building and for every 3000 square feet of floor area under construction.

B. Locate portable fire extinguishers 50 feet maximum from any point in the protection area.

1.3 FIRE PREVENTION AND SAFETY MEASURES

A. Prohibit smoking in all hazardous areas and in all of the OWNER'S buildings. Post suitable warning signs in areas which are continuously or intermittently hazardous.

B. Use metal safety containers for storage and handling of flammable and combustible liquids.

C. Do not store flammable or combustible liquids in or near stairways or exits.

D. Maintain clear exits from all points in the Work site.

1.4 COSTS OF INSTALLATION

A. Pay all costs including installation, maintenance, and removal.

1.5 HAZARDOUS MATERIALS RELEASE EVACUATION

A. Be familiarized with the OWNER'S hazardous materials release evacuation plan and shall have the Work force prepared to evacuate should the emergency occur.

B. The OWNER will conduct a training session for CONTRACTOR'S supervisory staff, which would be responsible to train all of CONTRACTOR'S employees, all Subcontractors' employees or any other personnel who are on site.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 01522

CONTRACTOR'S FIELD OFFICE AND SHEDS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Provide a CONTRACTOR'S field office with the minimum facilities specified. Provide all required storage and work sheds.

B. Field Office and Furnishings:
   1. As required by CONTRACTOR, but with sufficient room for project meetings.
   2. Include conference table and chairs sufficient for 20 persons.
   3. Telephone service.
   4. Temporary facilities per Section 01510 – Temporary Construction Facilities, Section 01511 – Temporary Electricity, Section 01512 Temporary Lighting, Section 01513 – Temporary Heat, Ventilation and Enclosure, Section 01514 – Temporary Water, Section 01515 – Temporary Sanitary and First Aid Facilities, Section 01516 – Temporary Fire Protection.
   5. Twelve protective helmets for visitor's use.
   6. Exterior identifying sign.
   7. Other furnishings at CONTRACTOR'S option.
   8. Company sign no larger than 4-feet by 8-feet.

C. Provide one set of all Contract Documents in the office for ready reference at all times by interested parties.

D. Storage and Work Sheds:
   1. Provide storage and work sheds sized, furnished, and equipped to accommodate personnel, materials and equipment involved, including temporary utility services.

E. Remove office and sheds upon Final Acceptance, unless otherwise approved by ENGINEER.

F. Pay for any and all permits that may be required.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 01550

ACCESS ROADS AND PARKING AREAS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Provide all temporary construction roads, walks and parking areas required during the construction and for use of emergency vehicles. Temporary roads and parking areas shall be designed and maintained by CONTRACTOR so as to be fully usable in all weather conditions.

B. Prevent interference with traffic and the OWNER'S operations on existing roads. Indemnify and save harmless the OWNER from any expenses caused by CONTRACTOR'S operations over these roads.

C. Roadway damage shall be restored to the original condition by CONTRACTOR subject to approval of the OWNER or ENGINEER.

D. Temporary roads, walks and parking areas shall be removed by CONTRACTOR, prior to Final Acceptance, and the ground returned to its original condition, unless otherwise required by the Contract Documents.

1.2 DESIGNATED PARKING

A. All CONTRACTOR'S employee vehicles shall park in an area specifically designated for that purpose, as more fully described in Section 01561, Security.

1.3 MAINTENANCE OF ROADS

A. At all times maintain approved access for trucks to loading areas of the plant and parking facilities for plant personnel. All parking of construction vehicles shall be in approved lots.

B. Have all paved roads impacted by the Work swept by mechanical sweeper, a minimum once per week or as directed by the OWNER. Keep roads serviceable at all times. Specific roads include:
   1. All roads within the limits of this Contract.
   2. Plant roads from entrance to work parking and work sites.

C. Dust resulting from construction shall be controlled by CONTRACTOR to prevent a nuisance on the site or in adjacent areas. Apply water or use other methods subject to the ENGINEER'S approval, which will keep dust in the air to a minimum. Use of water will not be permitted when it results in hazardous or objectionable

conditions such as ice, mud, ponds and pollution, refer to Section 01414, Earthmoving and Dust Control.

D. Provide temporary heavy duty steel roadway plates to protect existing manholes, handholes, valve boxes and vaults.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 01551

MAINTENANCE AND PROTECTION OF TRAFFIC

PART 1 - GENERAL

1.1 DESCRIPTION

A. All streets and trafficways shall be kept open for the passage of traffic and pedestrians during the construction period, unless otherwise approved by the ENGINEER, in writing, or authority having jurisdiction over same. Construction traffic at the site shall only use the entrances stated in Section 01561- Security.

B. When required to cross, obstruct or temporarily close a street or trafficway, provide and maintain suitable bridges, detours or other approved temporary expedient for the accommodation of traffic. Closings shall be for the shortest time practical, and passage shall be restored immediately after completion of backfill and temporary paving or bridging.

C. Give the required advance notice to the fire and police departments of proposed operations.

D. Give reasonable notice to owners or tenants of private property who may be affected by CONTRACTOR'S operations. A minimum 14 calendar days notice shall be given.

E. Provide signs, signals, barricades, flares, lights and all other equipment, service and personnel required to regulate and protect all traffic and warn of hazards. All such work shall conform to requirements of the OWNER or authority having jurisdiction. Remove temporary equipment and facilities when no longer required, and restore grounds to original or to specified conditions.

1.2 TRAFFIC SIGNALS AND SIGNS

Provide and operate traffic control and directional signals required to direct and maintain an orderly flow of traffic in all areas under CONTRACTOR'S control, or affected by CONTRACTOR'S operations.

B. Provide traffic control and directional signs, mounted on barricades or standard posts at the following locations:
   1. Each change of direction of a roadway and at each crossroad.
   2. Detours and hazardous areas.
   3. Parking areas.

1.3 FLAGMEN

A. Provide qualified and suitably equipped flagmen when construction operations encroach on traffic lanes, as required for regulation of traffic and in accordance with the requirements of the authority having jurisdiction.

1.4 FLARES AND LIGHTS

A. Provide flares and lights during periods of low visibility:
   1. To clearly delineate traffic lanes, to guide traffic and to warn of hazardous areas.
   2. For use by flagmen in directing traffic.

B. Provide illumination of critical traffic and parking areas.

1.5 PARKING CONTROL

A. Control all CONTRACTOR related vehicular parking within the limits of the Work to preclude interference with public traffic or parking, access by emergency vehicles, OWNER'S operations, or construction operations. Provide temporary parking facilities for the public, as may be required because of construction or operations.

B. Monitor parking of all construction and private vehicles:
   1. Maintain free vehicular access to and through parking areas.
   2. Prohibit parking on or adjacent to access roads or in non-designated areas.
   3. All construction vehicles must possess current registration.
   4. Private vehicles shall park only in the designated areas.

1.6 HAUL ROUTES

A. Consult with governing authorities and establish thoroughfares which will be used as haul routes and site access.

B. Drawings indicate haul routes which have been designated by authorities to be used for construction traffic.

C. Submit requested routes to ENGINEER and OWNER for designation as haul route and secure approval of authorities.

D. Confine construction traffic to designated haul routes.

E. Provide traffic control at critical areas of haul routes to expedite traffic flow, and to minimize interference with normal public traffic.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION +

SECTION 01561

SECURITY

PART 1 - GENERAL

1.1 DESCRIPTION

A. Safely guard all Work, materials, equipment and property from loss, theft, damage and vandalism. CONTRACTOR'S duty to safely guard property shall include the OWNER'S property and other private property from injury or loss in connection with the performance of the Work.

B. Employ watchmen as required to provide the required security and prevent unauthorized entry.

C. Make no claim against the OWNER for damage or injury resulting from trespass.

D. Responsible for security and shall make good all damage to property of OWNER and others arising from failure to provide adequate security. The standard for security shall be, at a minimum, equivalent to the owner's standards.

E. If the existing fencing or barriers are breached or removed for purposes of construction, provide and maintain temporary security fencing equal to the existing in a manner satisfactory to the ENGINEER and OWNER. Provide additional security staff, if required, to maintain the security of the facility.

F. Security measures taken shall be at least equal to those usually provided by OWNER to protect his existing facilities during normal operation.

G. Maintain security program throughout the Work until OWNER'S acceptance and occupancy precludes need for CONTRACTOR'S security program.

H. Comply with all aspects of OWNER'S site specific Security Guard Protocol. This shall include background checks equivalent to those conducted by the owner.

I. All costs for security as specified in this Section shall be borne by CONTRACTOR.

1.2 CONTRACTOR'S ACCESS TO THE WORK SITE (SITE)

A. Access to the site for CONTRACTOR'S employees, material, tools and equipment shall be from the designated construction entrance indicated on the Drawings.

B. Ensure that each of his employees, representatives, delivery persons, suppliers and others acting for CONTRACTOR, shall be subject to the following regulations:
   1. CONTRACTOR'S subcontractor's, suppliers and manufacturer's employee's shall not park anywhere other than CONTRACTOR Employee's Parking Area. The Area shall be designated by the ENGINEER. Prepare and maintain this area, as required.
   2. All CONTRACTOR employees shall wear a laminated photograph identification and badge bearing CONTRACTOR'S name, employee's name, and employee number at all times when the employee is on the site. Badge and Background Check Data form shall be completed by CONTRACTOR and approved by OWNER prior to CONTRACTOR personnel entering the site.
   3. Turn over the identification badge to the OWNER upon the individual's completion of the participation on the project or project completion.
   4. OWNER reserves all rights to the approval of all CONTRACTOR, subcontractor, suppliers and manufacturers employees receiving an identification badge.
   5. All vehicles, including those belonging to CONTRACTOR, his employees and subcontractors, delivery persons and suppliers entering the plant site shall conform to all security and safety regulations in force at the site. All vehicles entering and leaving the facility are subject to search.
   6. Personal vehicles shall not be allowed outside CONTRACTOR'S Employee Parking Area.
   7. Delivery vehicles shall access the site from the designated construction entrance road stated in Paragraph 1.2 A. above.
   8. Access to the site from any other entrance is strictly prohibited, unless prior approval is obtained from the owner. Violators shall be banned from the site.
   9. Firearms are not allowed on City property.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 01570

TEMPORARY CONTROLS

PART 1 - GENERAL

1.1 DESCRIPTION

A. The CONTRACTOR shall provide and maintain methods, equipment, and temporary construction, as necessary to provide controls over environmental conditions at the construction site and adjacent areas. Remove physical evidence of temporary facilities at completion of Work.

B. The CONTRACTOR shall obtain all City, County and State permits required for the construction of all Work, including Hazardous Material Management, Earth Moving/ Dust Control and Stormwater/Stormwater Pollution Prevention Permits.

1.2 NOISE CONTROL

A. CONTRACTOR'S vehicles and equipment shall be such as to minimize noise to the greatest degree practicable. Noise levels shall conform to the latest OSHA standards and in no case will noise levels be permitted which interfere with the Work of the OWNER or others.

1.3 PEST AND RODENT CONTROL

A. Provide rodent and pest control as necessary to prevent infestation of construction or storage areas.
   1. Employ methods and use materials that will not adversely affect conditions at the site or on adjoining properties.

1.4 WATER CONTROL

A. Provide methods to control surface water and water from excavations and structures to prevent damage to the Work, the site, or adjoining properties.
   1. Control fill, grading and ditching to direct water away from excavations, pits, tunnels and other construction areas and to direct drainage to proper runoff courses so as to prevent any erosion, damage or nuisance.

1.5 EROSION CONTROL

A. Plan and execute construction and earth work by methods to control surface drainage from cuts and fills, and from borrow and waste disposal areas, to prevent erosion and sedimentation.
   1. Hold the areas of bare soil exposed at one time to a minimum.
   2. Provide temporary control measures such as berms, dikes and drains.

B. Construct fills and waste areas by selective placement to eliminate surface silts or clays which will erode.

C. Periodically inspect earthwork to detect any evidence of the start of erosion; apply corrective measures as required to control erosion.

D. Coordinate erosion control requirements with the requirements of Article 1.4, above.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 01580

PROJECT IDENTIFICATION AND SIGNS

PART 1 GENERAL

1.1 DESCRIPTION

A. Furnish, install and maintain temporary project identification and informational signs.

B. The following signs shall be provided:
   1. NON-POTABLE WATER: at all non-potable water hose valves.
   2. REMOTELY CONTROLLED AUTOMATIC EQUIPMETN: on front and back of equipment and control panels that starts automatically by remote control.
   3. HIGH VOLTAGE WARNING: On front and back of all electrical panels and adjacent to doors to rooms containing devices that operate at 480V or greater.
   4. Metal traffic signs: Type and lettering as indicated on the Drawings.

C. No signs, except those specified, shall be displayed, unless approved by OWNER.

1.2 SUBMITTALS

A. Submit for approval the following:
   1. Type of grade of materials.
   2. Layout, size, trim, framing, supports and coatings.
   3. Size and style of lettering.
   4. Samples of colors.

1.3 CONSTRUCTION

A. Use 3/4-inch exterior grade plywood, unless shown otherwise.

B. Use, trim, mitered on all edges.

C. Design signs and supports to withstand 75 mile per hour wind.

D. Paint with exterior gloss-finish enamel. Sign painter shall be a professional in the type work required.

1.4 INSTALLATION AND MAINTENANCE

A. Location of signs shall be as shown or directed by ENGINEER.

B. Maintain signs so they are clean, legible and upright. Keep grass and weeds cut away from signs.

C. Repair and repaint damaged signs. Relocate signs as required by progress of the Work.

D. Remove signs when project is completed or when directed by ENGINEER.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 01600

GENERAL EQUIPMENT PROVISIONS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. These General Equipment Provisions apply, to all equipment furnished under this Contract including equipment specified in Division 11, Equipment, Division 13, Special Construction, Division 14, Conveying Systems, Division 15, Mechanical, Division 16, Electrical, and Division 17, Instrumentation. These General Provisions shall supplement the Detailed Equipment Specifications, but in case of conflict the Detailed Equipment Specifications shall govern.

B. Environmental Conditions:
   1. All equipment and appurtenances specified in the scope of this Section shall be designed and configured for installation and operation in a corrosive environment.
   2. Equipment shown or specified for exterior locations shall be designed for continuous operation in a dusty environment, with normal ambient air temperatures of 120°F, and exposed to air that contains corrosive compounds.

1.2 QUALITY ASSURANCE

A. Arrangement:
   1. The arrangement of equipment shown on the Drawings is based upon information available to the ENGINEER at the time of design and is not intended to show exact dimensions peculiar to a specific manufacturer. The Drawings are, in part, diagrammatic, and some features of the illustrated equipment installation may require coordination to meet actual equipment installation requirements. Structural supports, foundations, connected piping, valves, and electrical conduit specified may have to be coordinated to accommodate the equipment provided. No additional payment will be made for the coordination.

B. Unit Responsibility:
   1. Equipment systems made up of two or more components shall be manufactured and assembled as a unit by the responsible manufacturer. The responsible manufacturer shall select all components of the system to assure compatibility, ease of construction and efficient maintenance. The responsible manufacturer shall coordinate selection and design of all system components, such that all equipment furnished under the specification for the equipment

system, including equipment specified elsewhere, but referenced in the specification, is compatible and operates properly to achieve the performance requirements specified. Unless otherwise specified, the responsible manufacturer shall be the manufacturer of the driven equipment. Agents, representatives or other entities that are not a direct component of the manufacturing corporation will not be acceptable as a substitute for the manufacturer's corporation in conforming to this requirement. This requirement for unit responsibility shall in no way relive CONTRACTOR of his responsibility to the OWNER for performance of all systems.

2. Assure that all equipment systems provided for the Project are products for which unit responsibility has been accepted by the responsible manufacturer. Where the detailed specification requires a certificate from the Unit Responsibility Manufacturer, coordinate delivery of such certificates. Certificates shall conform to the content, form and style of Form 01600-B specified in Section 01331, Reference Forms, shall be signed by an officer of the manufacturer's corporation and shall be notarized. No other submittal material will be processed until a Certificate of Unit Responsibility has been received and has been found to be satisfactory. Failure to provide acceptable proof that the unit responsibility requirement has been satisfied will result in withholding approval of progress payments for the subject equipment even though the equipment may have been installed in the Work.

1.3 WORKMANSHIP AND MATERIALS

A. All equipment shall be designed, fabricated and assembled in accordance with the best modern engineering and shop practice and in accordance with applicable standards. Individual parts shall be manufactured to standard sizes and gauges so that repair parts, furnished at any time, can be installed in the field. Like parts of duplicate units shall be interchangeable. Equipment shall not have been in service at any time prior to delivery, except as required for tests.

B. In various Sections of the Specification, manufacturer's names have been used for clarity and to establish minimum product standards only. Responsibility for selection and coordination of all materials required for construction belongs to CONTRACTOR.

C. All parts and components of mechanical equipment shall be designed for satisfactory service under continuous duty and under the specified and indicated operating conditions. Any part of mechanical equipment that shows excessive wear or fails due to wear, under normal operating conditions, within the warranty period shall be considered as evidence of defective material or defective workmanship, and it shall be replaced by CONTRACTOR with equipment or parts to meet the specified requirements, at no additional cost to the OWNER.

D. Bronze which shall be in contact with water or any liquid, used in the manufacture of any equipment shall not contain aluminum or more than six percent zinc, and shall conform to ASTM B62, or equivalent.

E. Tolerances and clearances, shall be as indicated on the Shop Drawings, and these tolerances and clearances shall be closely followed to secure proper operation of the equipment.

F. All flanges on equipment and equipment appurtenances furnished shall conform in dimensions and drilling to ANSI B16.1, Class 150, unless otherwise noted.

G. Responsibility to coordinate compatible materials of construction for all elastomer components for all seats, seals, gaskets, etc., for each process application belongs to CONTRACTOR. Acceptable compatible materials of construction for all elastomer materials are as follows:

Process Fluid	*Compatible Materials of Construction*
Ferric Chloride	Buna, EPDM, Teflon, Viton
Hydrochloric Acid	Teflon, Viton
Sodium Hydroxide	Teflon, Hypalon, Polypropylene, EPDM
Sodium Hypochlorite	Teflon, PVDF, Hypalon, Polypropylene
Polymer	Viton, Teflon
Methanol	Buna-N, Teflon

1.4 MANUFACTURER'S NAMES

A. Manufacturer's name and catalog numbers are for the convenience of CONTRACTOR. The detailed Contract Documents shall apply in the event of a conflict. If detailed Contract Documents have not been given, the manufacturer's name and catalog number shall determine the design criteria for comparison should an equal be submitted.

1.5 REGULATIONS AND CODES

A. Electrical and Instrumentation Work, furnished with equipment supplied under Division 11, Equipment, Division 13, Special Construction, Division 14, Conveying Systems, and Division 15, Mechanical, including connection to electrical equipment integral with mechanical equipment, shall be performed in accordance with the requirements of Division 16, Electrical, and Division 17, Instrumentation. When applicable, the material used in the performance of the electrical Work shall be approved by the Underwriter's Laboratories, Inc. (UL) for the class of service for which they are intended.

1.6 BEARINGS

A. Unless otherwise specified, all equipment bearings shall be oil or grease lubricated and ball or roller antifriction type of standard manufacture. Bearings shall be conservatively designed to withstand all stresses of the service specified. Each bearing, except as otherwise noted, shall be rated in accordance with the latest revisions of Anti-Friction Bearing Manufacturer's Association's (AFBMA) Methods of Evaluating Load Ratings of Ball and Roller Bearings for B-10 rating life of 100,000 hours.

B. All grease lubricated bearings, except those specified to be factory sealed lubricated, shall be fitted with easily accessible grease supply, flush, drain, and relief fittings of the standard hydraulic type. Extension tubes shall be provided for easy access.

C. Oil-lubricated bearings shall be equipped with either a pressure lubricating system or a separate oil reservoir type system. Each oil lubrication system shall be of sufficient size to safely absorb the heat energy normally generated in the bearing under a maximum ambient temperature of 55°C and shall be equipped with a filler pipe and an external level gauge. Fittings for pressure lubrication shall be 1/4-inch straight type.

D. To avoid work hardening or "Brinelling" damage from vibration, bearings shall be separately packed or otherwise suitably protected during transport.

1.7 LUBRICATION AND LUBRICATION FITTINGS

A. Equipment shall be adequately lubricated by systems that require attention no more often than weekly during continuous operation. Lubrication systems shall not require attention during startup or shutdown and shall not waste lubricants. Lubricants of the type recommended by the equipment manufacturer shall be provided in sufficient quantity for consumption prior to completion of required testing and commissioning of equipment. Provide the ENGINEER at Substantial Completion of the Project or portion of the Project, 4 hard copies and one digital PDF copy of a list showing the proper lubricants for each item of mechanical equipment, approximate quantities needed per year of continuous operation, and recommended lubrication intervals. Wherever possible, the types of lubricants shall be consolidated with the manufacturer's approval to minimize the number of different lubricants required for plant maintenance.

B. Equipment and bearing lubrication fittings shall be extended with piping beyond obstructions, such as guards or covers, to provide ease of lubrication without disassembly of the unit.

C. All lubrication fittings shall be constructed of Type 304L stainless steel and shall be brought to the outside of all equipment so they are readily accessible from the outside without the necessity of removing covers, plates, housing, or guards. Fittings shall be of button head type. Lubrication fittings shall be mounted together wherever possible and shall be made of factory-mounted multiple fitting assemblies. Fittings shall not be individual fittings field-mounted together.

D. Lubrication: Food grade oil meeting NSF 61 for water applications or oil bath for wastewater applications.

1.8 EQUIPMENT BASES AND BEDPLATES

A. A heavy cast iron, FRP, or stainless steel base shall be provided for each item of equipment that is to be installed on a concrete base, in accordance with the equipment manufacturer's requirements. Equipment assemblies, unless otherwise specified or shown on the Drawings, shall be mounted on a single, heavy, cast iron, FRP, or stainless steel bedplate, in accordance with the equipment manufacturer's requirements. Bases and bedplates shall be provided with machined support pads, tapered dowels for alignment of mating or adjacent items, adequate openings to facilitate grouting, and openings for electrical conduits. Seams and contact edges between stainless steel plates and shapes shall be continuously welded and ground smooth. Bedplate drain fittings shall be piped to the nearest sump or designated drainage area.

B. After assembly and installation on the concrete base, each unit shall be leveled, using a precision level, and aligned in place but not grouted until after the initial fitting and alignment of connecting piping. Each unit shall then be grouted to the concrete base. Each base and bedplate shall be completely filled with grout, where applicable. The grout shall extend to the edge of each base or bedplate and shall be beveled at 45 degrees all around the unit. Grout exposed at horizontal surfaces shall be rounded to provide drainage to appropriate points. After grout has set, jacking screws shall be removed, and nuts on anchor bolts shall be tightened followed by an overall check on leveling and alignment. Should equipment not meet tolerances of leveling and alignment, as recommended by the manufacturer, corrective measures shall be taken to obtain the tolerances required. Reciprocating equipment shall be grouted with non-shrinking epoxy grout, as specified under Section 03600, Grout.

1.9 EQUIPMENT GUARDS

A. Belt or chain drives, fan blades, couplings, exposed shafts, and other moving or rotating parts shall be covered on all sides by guards conforming with the General Industry Safety Orders of the Arizona Division of Industrial Safety. The guards shall be fabricated from 15 USS gauge or heavier aluminum or Type 316 stainless steel. Each guard shall be designed for easy installation and removal. Necessary

supports and accessories shall be provided for each guard. Guards in outdoor locations shall be designed to prevent the entrance of rain and dripping water. Drawings of the guards shall be submitted to the ENGINEER for approval prior to fabrication or delivery.

B. Secure guards in position by aluminum or Type 316 stainless steel braces or straps, securely fastened to floor, wall, or frame of the equipment. Fastenings shall permit easy removal for servicing the equipment.

1.10 EQUIPMENT DATA NAMEPLATES

A. Manufacturers nameplates shall meet requirements as stated in individual equipment specifications. Manufacturers equipment data nameplates shall be stamped on Type 316 stainless steel and fastened to the equipment in an accessible location with No. 4 or larger oval head Type 316 stainless steel screws or drive pins. The nameplate shall include manufacturer's name, equipment model number, serial number, drive speed, motor horsepower, and rated capacity etc. Manufacturers nameplates for pumps shall also include, at a minimum, rated total dynamic head, impeller size and capacity, where applicable.

B. All storage tanks (steel, fiberglass and polyethylene), shall include a second sign with the description of the contents. The lettering on the sign shall be visible from at least ten feet.

C. Refer to Section 01630 for CMMS Tag requirements.

1.11 WARNING SIGNS

A. Furnish and install permanent warning signs at all mechanical equipment, prior to startup, that may be started automatically or from remote locations. Signs shall be located near the equipment, in accordance with safety regulations, and shall be suitable for exterior use.

B. Warning signs shall be colored yellow with black letters, on not less than 18 gauge vitreous enameling stock. Copy shall read:

CAUTION:
THIS EQUIPMENT STARTS
AUTOMATICALLY

C. Each sign shall be clearly readable from a distance of 20 feet.

D. Additional warning sign requirements are specified in Section 10400, Identification Devices.

1.12 EQUIPMENT PAINTING/COATINGS

A. Surfaces requiring painting or coating for corrosion protection shall be smooth, free from sharp edges, burrs, and projections and shall have all welds ground smooth and all edges and corners of structural members rounded. Non-conformance shall be grounds for rejection of equipment, as determined by the ENGINEER.

B. Equipment shall be shop-primed prior to delivery to the Work site, unless otherwise specified, in accordance with Section 09900, Painting.

C. Surfaces of equipment, which will be inaccessible after assembly, shall be painted or otherwise protected before assembly by a method that provides protection for the life of the equipment. Furnish equipment to replace any equipment that the ENGINEER determines to be damaged beyond repair by rust or mishandling, etc., while in storage or during installation by CONTRACTOR.

D. Manufacturers equipment or motor data nameplates shall not be painted.

E. The equipment supplier shall certify, by a letter included with the equipment submittal, confirming that the proposed primer and finish coating used is compatible with the approved Division 9, Finishes, painting scheme. After delivery to the Work site, the equipment finished surfaces shall be inspected and evaluated. A final coat of paint shall be applied to all equipment in the field .

F. Machined, polished, and other ferrous and non-ferrous surfaces that are not to be painted shall be coated with rust preventative compound, Dearborn Chemical "NO-Ox-Id", Houghton "Rust Veto 344," Rust-oleum "R9," or approved equal. Should rust occur during shipment or storage, responsibility for correction, as determined by the ENGINEER, belongs to CONTRACTOR.

G. Copper, bronze, chromium plate, nickel, stainless steel, aluminum, monel metal, lead, lead coated copper, brass, and plastic are not to be painted or finished, unless otherwise specified or recommended by the manufacturer.

H. All metallic surfaces requiring a shop applied primer shall be primed with an approved priming system that has been certified, by letter, as being compatible with the Division 9, Finishes, coating systems proposed and shall be applied in accordance with the recommendations of the paint manufacturer. Submittal for equipment shall include:
   1. Coating manufacturer's "Cut-sheet" describing components, surface preparation requirements, recommended mil thicknesses, and application procedures for the proposed primer.
   2. A letter from the equipment supplier stating that he has confirmed that the proposed primers are compatible and that the primer will be applied in accordance with the coating manufacturer's requirements. In addition, the

letter shall certify that the appropriate surface preparations will be made prior to primer application.

I. After delivery to the Work site, equipment surfaces shall be inspected and evaluated by the ENGINEER. Touch-up or complete removal of shop priming, by sandblasting or other approved method, may be required as determined by the ENGINEER based on the condition of the equipment primer prior to final, in place, finish coat application.

J. Field touch-up, final surface preparation, and final finish coatings shall be applied by CONTRACTOR.

1.13 FACTORY TEST AND CERTIFICATION

A. All equipment, devices, and systems requiring factory test and certification, as specified in these Specifications, may be witnessed by the OWNER. Notify the ENGINEER, in writing, at least 30 calendar days in advance of all equipment, devices and system testing. The written notifications shall specify the exact date and location of the tests that will be conducted and shall define the test procedures to be utilized. Testing procedure shall be scheduled and performed during normal working hours and shall be subject to review by the ENGINEER.

1.14 VARIABLE FREQUENCY DRIVES

A. Variable frequency drives, motors, and pumps furnished by OWNER shall be installed by CONTRACTOR and tested in accordance with Paragraph 1.14.C., below.

B. Unit Responsibility:
   1. Have unit responsibility for proper coordination and compatibility of all Variable Frequency Drives (VFDs) and controls furnished under Division 16, Electrical, with the Division 11, Equipment, equipment and motors specified in the Contract Documents, and shall have total responsibility for the satisfactory installation and operation of the entire driven system, including driven equipment, motors, drives, and controls as specified in the Contract Documents.
   2. The Division 11, Equipment, manufacturer shall assume sole unit responsibility for the equipment and motors, and shall assume responsibility that the motors supplied with the equipment will successfully operate the equipment over the specified operating speed range. The equipment package, including motors, shall operate successfully over the speed range and all other operating characteristics provided by VFDs.
   3. The motor manufacturer shall submit written approval, in letter form, of the VFD to be furnished as part of the submittal package. The equipment manufacturer shall perform field testing necessary to confirm compatibility of

the drives with successful operation of the equipment throughout the complete operating range specified.

4. The Division 11, Equipment, manufacturer shall review the location of and relationship of the VFD with respect to the driven equipment and motor, and certify, in writing, the relationship will satisfactorily operate the unit(s) for its intended normal operating lifetime.

C. Testing:
   1. Field Acceptance Testing: After installation of the system at the Work site and checkout by the drive manufacturer, a field acceptance test shall be conducted jointly by the drive manufacturer and the manufacturer of the driven equipment.
      a. The field acceptance test shall consist of repeating the factory acceptance testing procedure and an additional 24 hours of similar testing, during which the system shall run continuously without loss of basic functions. Functional tests shall demonstrate satisfactory operation of all interlocks, alarms, and normal operating sequences. The drive manufacturer shall use suitable test equipment to identify and correct malfunctions. Failure of redundant equipment will not be considered as downtime, provided that automatic failover occurs as specified herein and, that in the opinion of the ENGINEER, the failure was not caused by deficiency in design or installation. Repeated failure of any component shall be cause for the acceptance test to be terminated and restarted.
      b. Verify that harmonics comply with the requirements of IEEE-519 at the motor control center.

1.15 EQUIPMENT INFORMATION FORMS

A. Complete Form 01600-A found in Section 01331, Reference Forms, for all equipment and devices that are specified in the Contract Documents. This includes each component mounted as a package, or "skid" mounted equipment and control panels. The completed Equipment Information Forms shall be included in the individual Operation and Maintenance Manuals.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 01610

PRE-PURCHASED EQUIPMENT COORDINATION

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section describes Work necessary to coordinate shipment, delivery, storage, installation, and commissioning of all pre-purchased equipment.

B. A portion of the major equipment has been pre-purchased by the OWNER. The approved submittals for all pre-purchased equipment are included for reference under a separate cover with the contract as follows:
   1. Attachment A – Pre-purchased submersible pump submittals
   2. Attachment B – Pre-purchased valve submittals
   3. Attachment C – Pre-purchased variable frequency drive submittals

C. Information provided in submittals, Shop Drawings, installation drawings and instructions furnished by the manufacturers shall be used by CONTRACTOR for shipment, delivery, storage, installation and commissioning in the installation of the equipment and materials.

1.2 SHIPMENT, DELIVERY, STORAGE, INSTALLATION, AND COMMISSION

A. Conform to all requirements indicated in of Section 01600, General Equipment Provisions, 01620, Installation of Equipment, and Section 01651, Transportation and Handling of Equipment and Materials.

B. All pre-purchased equipment shall be delivered freight-on-board to the Project location unless specifically coordinated and approved by the OWNER and ENGINEER.

C. The CONTRACTOR shall be responsible to coordinate the means and methods of shipment, delivery, offloading, storage, installation, and commissioning with the manufacturer for all pre-purchased equipment and in accordance with the Project schedule. All shipment, delivery and offloading and storage shall be in accordance with the manufacturer’s written instructions.

D. The CONTRACTOR shall provide the OWNER and ENGINEER written notification not less than 30 days prior to delivery date. Written notification to the OWNER and ENGINEER shall also be provided not less than 48 hours from anticipated hour of delivery.

The CONTRACTOR shall inspect all of the pre-purchased equipment upon delivery to verify the condition and general quantities for basis of payment.

The OWNER reserves the right to inspect any or all of the pre-purchased equipment upon delivery. The OWNER also reserves the right to refuse delivery of any pre-purchased equipment that is deemed damaged or defective.

1.3 SERVICES OF MANUFACTURERS' REPRESENTATIVE

A. All pre-purchased equipment shall include the cost of competent, qualified representatives of manufacturers of all equipment to supervise the installation, adjustment and testing of the equipment and to instruct the OWNER'S operating personnel on operation and maintenance. The training time and additional requirements for furnishing services of manufacturers' representatives are specified in the appropriate Sections. If no time is specified, the training time shall be at least one day. Supervision may be divided into two or more time periods as required by CONTRACTOR'S schedule or as directed by ENGINEER.

B. Upon completion of the equipment installation, submit "Equipment Information Form", Form 01600-A located in Section 01331, Reference Forms. The completed form shall also be included in the individual Operation and Maintenance Manuals.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION + +

ATTACHMENT A
PRE-PURCHASED SUBMERSIBLE PUMP SUBMITTALS

ATTACHMENT B
PRE-PURCHASED VALVE SUBMITTALS

ATTACHMENT C
PRE-PURCHASED VARIABLE FREQUENCY DRIVE SUBMITTALS

SECTION 01620

INSTALLATION OF EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section describes Work necessary to install equipment and materials to be incorporated into this Project. It supplements the Specification requirements in Division 2, Sitework, through Division 17, Instrumentation.

B. Shop Drawings, installation drawings and instructions furnished by the manufacturers shall be used by CONTRACTOR in the installation of the equipment and materials.

1.2 ANCHOR BOLTS AND GROUT

A. Anchors and adhesive anchors shall be furnished by CONTRACTOR, as specified and required. Use adhesive anchors only where shown or approved by ENGINEER or required by the manufacturer. Anchors and adhesive anchors shall be of specified materials with heavy hexhead nuts. Anchorage items shall conform to the applicable requirements of Section 05051, Anchor Bolts, Expansion Anchors, Toggle Bolts and Concrete Inserts.

B. Grouting shall be in accordance with Section 03600, Grout, and Section 01600, General Equipment Provisions.

1.3 TRANSPORTING, HANDLING, AND INSTALLING OF EQUIPMENT AND MATERIALS

A. Conform to requirements of Section 01600, General Equipment Provisions, and Section 01651, Transportation and Handling of Equipment and Materials.

B. Employ competent mechanics experienced in the installation of the types of equipment and materials to be furnished, and shall ensure that all equipment and materials are installed in accordance with the recommendations of the manufacturers.

1.4 EQUIPMENT ERECTION

A. General: Conform to the following as a minimum:
   1. Use only mechanics, machinists or mill wrights skilled in the handling, setting, aligning, leveling and adjusting of the type of equipment and materials furnished.

2. Use only an oil bath heater to expand couplings, gears, etc. Do not force or drive them on equipment shafts, nor subject them to an open flame or torch.
3. Wedging shall not be permitted. Use the least number of flat shims possible in leveling equipment. Shims shall be clean and free of slags. Provide all shims, filling pieces, keys, packing, red or white lead grout, or other materials necessary to properly align, level and secure apparatus in place. When requested by ENGINEER, demonstrate that all elements so required are level and plumb. Grind as necessary to bring parts to proper bearing after erection.
4. Use proper tools in the assembly of equipment and materials to prevent deforming or marring the surface of shafts, nuts or other parts.
5. Tighten connections requiring gaskets evenly all around to ensure uniform stress over the entire gasket area.
6. Equipment and materials shall not be altered or repaired, and no burning or welding shall be permitted on any parts having machined surfaces, except by written permission of ENGINEER.
7. No rigging shall be done from any structure without the permission of ENGINEER. Responsibility for any damage to the structure resulting from this operation, belongs to CONTRACTOR.
8. Use tools, equipment and materials that shall not damage the structure or equipment.
9. Furnish and install plugs in lubrication holes to prevent entry of foreign material.
10. Electrical work, testing, lubricating and painting shall all comply with requirements of the applicable Section.

B. Setting and Erection:
1. All units shall be carefully set and aligned on their foundations, by qualified millwrights, after their sole plates have been shimmed to true alignment at the anchor bolts. Anchor bolts shall be set in place and the nuts tightened against the shims. Bedplates or wing feet of the equipment shall be further checked after securing to the foundations and, after confirmation of all alignments, the sole plates shall be finally grouted in place. Be responsible for the correct alignment of equipment with its associated piping. “Pipe springing” shall not be allowed.
2. Misaligned holes shall be reamed. “Driving” of bolts or keys shall not be permitted.

C. Jacking Screws and Anchor Bolts:
1. All equipment shall be anchored to supporting members by bolts or other connections to accommodate all operating forces and satisfy the seismic restraint requirements of the Phoenix Building Code for Zone 1 Seismic Area. Anchors shall provide resistance to a lateral force of at least 0.30 times the weight of the equipment, including its contents.
2. Jacking screws shall be provided in the heavy equipment bases and bedplates, and where required elsewhere, to aid in leveling during installation.

3. Anchor bolt setting drawings shall be delivered sufficiently early to permit setting the anchor bolts when the structural steel support frame is fabricated by others.
4. All anchor bolts and anchoring hardware shall be of Type 316 stainless steel. Adhesive anchors shall only be used where permitted by the ENGINEER and shall be Type 316 stainless steel. Alternate methods of anchoring to those shown on the Contract Documents shall meet the requirements of this Section and shall be submitted to the ENGINEER for review.

D. Alignment and Leveling:
1. Field check all shafts, couplings and sheaves for alignment and adjust to manufacturer's specifications where necessary.
2. Couplings shall be aligned while the equipment is free from all external loads.
3. Angular and parallel alignment shall be checked, and the actual alignment shall be recorded and submitted to ENGINEER. Alignment shall be within manufacturer's recommended tolerance.
4. Dial indicators shall be used for the checking of angular and parallel alignment. During rotation of the half couplings in performance of this test, they shall be maintained in the same relative position, and the dial indicator readings shall be taken at the same place on the circumference of the coupling.

E. Threaded Connections:
1. Apply a molybdenum disulfide, anti-seize compound to all threads in mechanical connections such as bolts, studs, cap screws, tubing, etc., unless otherwise specified.

F. Equipment Drive Guards:
1. Unless shown or specified otherwise, provide all equipment driven by open shafts, belts, chains, pulleys, sheaves, or gears with all-metal guards conforming to the requirements of Section 01600, General Equipment Provisions.

1.5 EQUIPMENT INSTALLATION

A. Obtain installation instruction booklets or other recommendations from the equipment manufacturers as to procedures for, sequence of, and tolerances allowed in equipment installation. In particular, the manufacturer's recommendations as to grout spaces required, type of grout to be used, and tolerances for level and alignment, both vertical and horizontal, shall be obtained and followed. One copy of this material shall be given to the ENGINEER prior to the installation of the equipment.

B. Whenever applicable, obtain the services of a manufacturer's representative specifically trained in erection of his equipment to supervise the installation. Be responsible for the proper alignment of all installed driven equipment and drives in accordance with the tolerance recommendation of the manufacturers for both

OWNER furnished and CONTRACTOR furnished equipment. Within 14 calendar days after installation, submit to the ENGINEER a letter from the manufacturer, on the manufacturer's letterhead, stating all equipment and components are installed in accordance with the manufacturer's requirements and installation instructions as described in these Specifications.

C. Skilled craftsmen experienced in installation of the equipment or similar equipment shall be used. Applicable specialized tools and equipment, such as precision machinist levels, dial indicators, and gauges shall be utilized as required in the installations. The Work shall be accomplished in a workmanlike manner to produce satisfactory equipment installation free of vibration or other defects.

D. Install all OWNER furnished equipment in accordance with the installation instructions, Shop Drawings and submittals provided by the equipment manufacturers and available at the OWNER'S offices for CONTRACTOR'S use.

E. Prior to installation of equipment, all sacking and concrete preparation shall be completed and the Work area shall be maintained in a broom-clean condition during the equipment installation.

F. No equipment and materials shall be altered or repaired, and no burning or welding shall be permitted on any parts having machined surfaces, except by written permission of the ENGINEER.

G. No rigging shall be done from any structure without the permission of the ENGINEER. Responsibility for any damage to the structure resulting from this operation, belongs to CONTRACTOR.

H. Only such equipment and materials as will not damage the structure or equipment and materials shall be used on the Work.

1.6 SPECIAL TOOLS

A. All special tools that are required to assemble, disassemble, repair, and maintain any item of equipment furnished under the terms of this Contract shall be furnished with the equipment. When special tools are provided, they shall be marked or labeled and a list of such tools shall be included with the maintenance and operation instructions for the equipment.

1.7 COORDINATION

A. Take all measurements for Work at the installation sites, verify all subcontractor's and manufacturer's drawings, shall be responsible for the proper installation within the available space of the apparatus specified and shown on the Drawings and shall

inform the ENGINEER of any variations and shall submit all proposed changes for review before making any changes.

1.8 SERVICES OF MANUFACTURERS' REPRESENTATIVE

A. Equipment furnished under Divisions 11, 13, 14, 15, 16 and 17 shall include the cost of competent, qualified representatives of manufacturers of all equipment to supervise the installation, adjustment and testing of the equipment and to instruct the OWNER'S operating personnel on operation and maintenance. The training time and additional requirements for furnishing services of manufacturers' representatives are specified in the appropriate Sections. If no time is specified, the training time shall be at least one day. Supervision may be divided into two or more time periods as required by CONTRACTOR'S schedule or as directed by ENGINEER.

B. Upon completion of the equipment installation, submit "Equipment Information Form", Form 01600-A located in Section 01331, Reference Forms. The completed form shall also be included in the individual Operation and Maintenance Manuals.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 01630

COMPUTERIZED MAINTENANCE MANGEMENT SYSTEM TAGS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals, as shown on the Drawings, specified and required to furnish and install the Computerized Maintenance Management System (CMMS) tag system.
   2. The extent of the CMMS tag system is specified herein and shown on the Drawings.
   3. The CMMS tag system includes, but is not necessarily limited to, the following:
      a. CMMS tags.
      b. Miscellaneous mechanical fasteners.

B. CMMS Tags:
   1. Provide sufficient quantity of identification tags for each piece of equipment listed in table 3.3.A. below.
   2. Provide a quantity of blank tags equal to 10% of the number of tags required above under article 1.1.B.1.

1.2 QUALITY ASSURANCE

A. Source Quality Control: All CMMS tags shall be the product of a single manufacturer.

1.3 SUBMITTALS

A. Samples: Submit for approval samples for color, materials and accessories required for the CMMS tag system. ENGINEER'S review of samples will be for color, material and fastener only. Compliance with all other requirements is the exclusive responsibility of CONTRACTOR.

B. Shop Drawings: Submit for approval the following:
   1. Fasteners and accessory items.
   2. Samples of actual equipment identification tags for five devices.

C. CMMS Tag List: Submit for approval the following:
   1. Submit the finalized list of all CMMS tags including any alterations to the list that occur during construction. The list shall be provided on a compact disc in Microsoft Excel format (latest version) and shall include columns as shown under 3.3.A, CMMS Tag Information

PART 2 - PRODUCTS

2.1 CMMS TAG

A. Material of Construction:
   1. Material: Aluminum
   2. Thickness: 0.020 inches
   3. Coating: Black enamel
   4. Size: 2-inches wide by 2-inches high
   5. Shape: Square with rounded corners
   6. Holes: One (1) 3/16-inch hole centered on one end of the tag

B. Engraving:
   1. Text location: CMMS tags shall be engraved with text centered on the tag.
   2. Lettering: Engraved Arial font 1/8-inch high characters. Stamped CMMS tags are not acceptable.
   4. Text quantity: CMMS tags shall accommodate at minimum five (5) lines of engraved text with a minimum of twenty (20) characters per line.
   5. CMMS Tag information:
      a. See Table 3.3.A., CMMS Tag Information
         1) After CONTRACTOR receives approved submittals from the ENGINEER or OWNER. ENGINEER or OWNER will provide the Asset ID for the equipment requiring a tag.

C. Fastener:
   1. Fasteners: 48-mil, stainless steel wire
   2. Fastener Clamp: Zinc double ferrule wire clamp.
   3. Alternate fasteners must be approved by ENGINEER.

D. Layout:
   1. Refer to article 3.3.B, below for an example of the CMMS tag layout.

E. Manufacturer and Model:
   1. Brady, Model 87637
   2. Seton
   3. Or equal

PART 3 - EXECUTION

3.1 INSPECTION

A. CONTRACTOR and his installer shall examine the substrates and conditions under which the CMMS tags are to be installed and notify ENGINEER, in writing, of conditions detrimental to the proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions have been corrected in a manner acceptable to ENGINEER.

3.2 INSTALLATION

A. Install CMMS tags and components at the locations shown on the Drawings or, if not shown, at the nearest control point of the corresponding equipment, i.e. the local control panel, near a manual actuator, on the equipment itself, at the electrical disconnect, etc. The CMMS tag shall not interfere with the normal operation of the equipment. Where the location of the CMMS tag is such that it is not easily visible or the association between the CMMS tag and the corresponding equipment is not obvious install tags as directed by the ENGINEER.

B. For submersible or below ground equipment at a facility or plant, install the tag above grade next to motor disconnect or attach to the underside of the valve box cover with adhesive epoxy.

C. Repair or replace damaged units as directed by ENGINEER.

3.3 EQUIPMENT INFORMATION

A. Example CMMS Tag Information:

Service Description	Equipment Name	Serial Key	Asset ID	Initial Installed or Purchased Year
"Filter-to-Waste"	*"Valve Actuator"*	*"SK:1234567"*	*"A-ID:9876543"*	*"2015"*

B. Example CMMS Tag Layout:

+ + END OF SECTION + +

SECTION 01651

TRANSPORTATION AND HANDLING OF MATERIALS AND EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION

A. Make all arrangements for transportation, delivery and handling of equipment and materials required for prosecution and completion of the Work.

B. Shipments of materials to CONTRACTOR or subcontractors shall be delivered to the site only during regular working hours and shall conform to the requirements of Section 01413, CONTRACTOR'S Hazardous Materials Management Program. Shipments shall be addressed and consigned to the proper party giving name of Project, street number and city. Shipments shall not be delivered to OWNER, except where otherwise directed.

C. If necessary to move stored materials and equipment during construction, move materials and equipment without any additional compensation.

1.2 PREPARATION FOR SHIPMENT

A. When practical, factory assemble products. Matchmark or tag separate parts and assemblies to facilitate field assembly. Cover machined and unpainted parts that may be damaged by the elements with a strippable protective coating.

B. Package products to facilitate handling and protect from damage during shipping, handling, and storage. Mark or label outside of each package or crate to indicate its purchase order number, bill of lading number, contents by name, OWNER'S contract name and number, CONTRACTOR, equipment number, and approximate weight. Include complete packing lists and bills of materials with each shipment.

C. Protect products from exposure to the elements and keep thoroughly dry and dust free at all times. Protect painted surfaces against impact, abrasion, discoloration, or other damage. Grease or oil all bearings and similar items.

D. Advance Notice to ENGINEER of Shipments: Upon receipt of manufacturer's advance notice of shipment, provide ENGINEER seven-day advance notice of anticipated date and place of arrival of the following:
   1. Submersible Pumps per Section 11318 – End Suction Submersible Pumps
   2. Biofilter Odor Control per Section 13126 – Packaged Biofilter Odor Control

E. Do not have products shipped until:
   1. Related Shop Drawings have been approved by ENGINEER.
   2. Related factory test results, required in the individual Specification Sections, have been reviewed and accepted by ENGINEER.
   3. Required storage facilities have been provided.

F. Items shall be supported, packaged and stored in such a way so as not to impose undue stress/forces to couplings, connections, supports, valves, equipment and instruments.

1.3 DELIVERY

A. Arrange, with the United States Postal Service, a special address for the Project. All deliveries shall be made to that address.

B. Arrange deliveries of products in accordance with construction schedules and in ample time to facilitate inspection prior to installation.

C. Coordinate deliveries to avoid conflict with Work and conditions on site and to accommodate the following:
   1. Work of other contractors, or OWNER.
   2. Limitations of storage space.
   3. Availability of equipment and personnel for handling products.
   4. OWNER'S use of premises.

D. Do not have products delivered to Project site until related Shop Drawings have been approved by the ENGINEER.

E. Do not have products delivered to Project site until required storage facilities have been provided.

F. Have products delivered to site in manufacturer's original, unopened, labeled containers. Keep ENGINEER informed of delivery of all equipment to be incorporated in the Work.

G. Partial deliveries of component parts of equipment shall be clearly marked to identify the equipment, to permit easy accumulation of parts and to facilitate assembly.

H. Immediately on delivery, inspect shipment to assure:
   1. Product complies with requirements of Contract Documents and reviewed submittal.
   2. Quantities are correct.
   3. Containers and packages are intact, and labels are legible.

4. Products are properly protected and undamaged.
5. Verify that the accelerometer recordings were made during shipment.

I. Promptly remove damaged products from the Project site and expedite delivery of new undamaged products, and remedy incomplete or lost products to provide that specified, so as not to delay progress of the Work.

1.4 PRODUCT HANDLING

A. Provide equipment and personnel necessary to handle products, including those provided by OWNER, by methods to prevent soiling or damage to products or packaging.

B. Provide additional protection during handling as necessary to prevent scraping, marring or otherwise damaging products or surrounding surfaces.

C. Handle products by methods to prevent bending or overstressing.

D. Lift heavy components only at designated lifting points.

E. Materials and equipment shall at all times be handled in a safe manner and as recommended by manufacturer or supplier so that no damage will occur to them. Do not drop, roll or skid products off delivery vehicles. Hand carry or use suitable materials handling equipment.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 01661

STORAGE OF MATERIALS AND EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION

A. Store and protect materials in accordance with manufacturer's recommendations and requirements of Specifications.

B. Make all arrangements and provisions necessary for the storage of materials and equipment. All excavated materials, construction equipment, and materials and equipment to be incorporated into the Work shall be placed so as not to injure any part of the Work or existing facilities and so that free access can be maintained at all times to all parts of the Work and to all public utility installations in the vicinity of the Work. Materials and equipment shall be kept neatly and compactly stored in locations that will cause a minimum of inconvenience to other contractors, public travel, adjoining owners, tenants and occupants. Arrange storage in a manner to provide easy access for inspection.

C. Areas available on the site for storage of materials and equipment shall be as shown or approved by the ENGINEER.

D. Materials and equipment, which are to become the property of the OWNER, shall be stored to facilitate their inspection and ensure preservation of the quality and fitness of the Work, including proper protection against damage by freezing, moisture and summer temperatures with ambient temperatures as high as 120°F. They shall be placed in inside climate storage areas, unless otherwise acceptable to OWNER. When placing orders to suppliers for equipment and controls containing computer chips, electronics and solid-state devices, request and coordinate specific temperature limitations on equipment since cabinets and components stored in the summer can approach temperatures of 200°F.

E. Be fully responsible for loss or damage, including theft, to stored materials and equipment.

F. Do not open manufacturer's containers until time of installation, unless recommended by the manufacturer or otherwise specified.

G. Do not store products in the structures being constructed, unless approved in writing by the ENGINEER.

H. Lawns, grass plots or other private property shall not be used for storage purposes without written permission of the OWNER or other person in possession or control of such premises.

1.2 PROTECTION

A. Equipment shall be boxed, crated or otherwise completely enclosed and protected during shipment, handling and storage. Each container or piece of equipment shall be clearly marked with CONTRACTOR'S name, project name and location. Equipment shall be stored on raised supports protected from exposure to the elements and shall be kept thoroughly dry at all times. Pumps, motors, drives, electrical equipment, instrumentation equipment (controls, devices, panels, etc.) and other equipment having anti-friction or sleeve bearings shall be stored in weathertight storage facilities, such as warehouses. Covering with visquine or similar material shall not be considered as a weathertight enclosure.

B. Painted surfaces shall be protected against impact, abrasion, discoloration and other damage. Painted equipment surfaces, which are damaged prior to acceptance, shall be repainted in entirety to the satisfaction of the ENGINEER.

C. Electrical equipment, controls, and instrumentation shall be protected against moisture, water damage, heat or dust. Space heaters provided in the equipment shall be connected and operating at all times until equipment is placed in operation.

D. Items shall be stored in such a way so as not to impose undue stress/forces to couplings, connections, supports, valves, equipment and instruments.

1.3 UNCOVERED STORAGE

A. The following types of materials may be stored outdoors without cover:
   1. Masonry units.
   2. Reinforcing steel.
   3. Structural steel.
   4. Piping, except PVC.
   5. Precast concrete items.
   6. Castings.

B. Store the above materials on wood blocking so there is no contact with the ground.

1.4 COVERED STORAGE

A. The following types of materials may be stored outdoors if covered with material impervious to water:
   1. Rough lumber.
   2. Handrailing.

3. PVC Piping.
4. Filter Media.

B. Tie down covers with rope and slope to prevent accumulation of water on covers.

C. Store materials on wood blocking or skids.

D. Store loose granular materials, covered with materials impervious to water, in a well-drained area or solid surfaces to prevent mixing with foreign matter.

1.5 FULLY PROTECTED STORAGE

A. Store all products not named above in buildings or trailers which have a concrete or wooden floor, a roof, and fully closed walls on all sides.

B. Provide heated storage space for materials which could be damaged by freezing.

C. Provide air-conditioned storage space for materials that could be damaged by Arizona's severe high temperatures.

D. Protect mechanical and electrical equipment from being contaminated by dust, dirt and moisture.

E. Maintain humidity at levels recommended by manufacturers for electrical and electronic equipment.

1.6 HAZARDOUS PRODUCTS

A. Prevent contamination of personnel, the storage area and the site. Comply with the requirements of the Specification Section 01413, CONTRACTOR'S Hazardous Materials Management Program, codes and manufacturer's instructions.

1.7 MAINTENANCE OF STORAGE

A. Maintain periodic system of inspection of stored products on a scheduled basis to assure that:
   1. State of storage facilities is adequate to provide required conditions.
   2. Required environmental conditions are maintained on a continuing basis.
   3. Products exposed to elements are not adversely affected.

B. Mechanical and electrical equipment which require long term storage shall have complete manufacturer's instructions for servicing each item with notice of enclosed instructions shown on exterior of package.
   1. Comply with manufacturer's instructions on a scheduled basis.

2. Space heaters which are part of electrical equipment shall be connected and operated continuously until equipment is placed in service.

1.8 PANEL AND INSTRUMENTATION STORAGE

A. All panels, microprocessor-based equipment and all other devices subject to damage or useful life decrease, because of temperatures below 40°F or above 100°F, relative humidity above 90 percent, or exposure to rain or exposure to blowing dust shall not be stored on site.

B. Storage shall be in an insured, climate-controlled warehouse within Maricopa County. The OWNER shall have the right to inspect the equipment during normal working hours. Placed inside each panel or device shall be a desiccant, volatile corrosion inhibitor blocks (VCI), a moisture indicator and maximum-minimum indicating thermometer. The panels and equipment shall be checked once per month. The desiccant, VCI and moisture indicator shall be replaced as often as required or every six months, whichever occurs first. A certified record of the daily maximum and minimum temperature and humidity in the warehouse shall be available for inspection by the OWNER. A certified record of the monthly inspection, noting maximum and minimum temperature for the month, condition of desiccant, VIC and moisture indicator, shall also be available for inspection by the OWNER.

C. All costs for the storage shall be at no additional cost to the OWNER. Any panel or device which has been damaged by any cause or for which the storage temperatures or humidity range has been exceeded shall be replaced at no additional cost to the OWNER and shall not be cause for a delay in Contract completion.

D. The panels and equipment shall not be shipped to the site until field conditions are ready for installation, including all slabs, walls, roofs, and environmental controls. The failure to have the site ready for installation shall not relieve CONTRACTOR from conforming to all of the Contract requirements.

1.9 RECORDS

A. Keep running account of products in storage to facilitate preparation of progress payments, if Agreement provides for payment for products delivered, but not installed in the Work.

B. A record shall be kept of the storage requirements and a continuous maintenance log for all stored equipment. A tag shall be applied to each piece of equipment showing all service dates and who did the service.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 01721

PROTECTION OF THE WORK AND PROPERTY

PART 1 - GENERAL

1.1 DESCRIPTION

A. Be responsible for taking all precautions, providing all programs, and taking all actions necessary to protect the Work and all public and private property and facilities from damage as specified in the General Conditions and herein.

B. In order to prevent damage, injury or loss, CONTRACTOR'S actions shall include, but not be limited to, the following:
   1. Store apparatus, materials, supplies, and equipment in an orderly, safe manner that will not unduly interfere with the progress of the Work or the work of any other contractor or utility service company.
   2. Provide suitable storage facilities for all materials which are subject to injury by exposure to weather, theft, breakage, or otherwise.
   3. Place upon the Work or any part thereof only such loads as are consistent with the safety of that portion of the Work.
   4. Clean up frequently all refuse, rubbish, scrap materials, and debris caused by his operations, to the end that at all times the site of the Work shall present a safe, orderly and workmanlike appearance.
   5. Provide barricades and guard rails around openings, for scaffolding, for temporary stairs and ramps, around excavations, elevated walkways and other hazardous areas.

C. Shall not, except after written consent from proper parties, enter or occupy privately-owned land with personnel, tools, materials or equipment, except on easements provided herein.

D. Assume full responsibility for the preservation of all public and private property or facility on or adjacent to the site. If any direct or indirect damage is done by or on account of any act, omission, neglect or misconduct in the execution of the Work by CONTRACTOR, it shall be restored by CONTRACTOR, at his expense, to a condition equal to that existing before the damage was done.

E. CONTRACTOR shall be responsible for any staking/roping needed to identify the contractual limits of construction activities.

1.2 BARRICADES AND WARNING SIGNALS

A. Where Work is performed on or adjacent to any roadway, right-of-way, or public place, provide barricades, fences, lights, warning signs, danger signals, watchmen,

and shall take other precautionary measures for the protection of persons or property and of the Work. Barricades shall be painted to be visible at night. From sunset to sunrise, furnish and maintain at least one light at each barricade. Sufficient barricades shall be erected to keep vehicles from being driven on or into Work under construction. Furnish watchmen in sufficient numbers to protect the Work. CONTRACTOR'S responsibility for the maintenance of barricades, signs, lights, and for providing watchmen shall continue until the Project is accepted by OWNER.

1.3 TREE AND PLANT PROTECTION

A. Protect existing trees, shrubs and plants on or adjacent to the site that are shown or designated to remain in place against unnecessary cutting, breaking or skinning of trunk, branches, bark or roots.

B. Materials or equipment shall not be stored or parked within the drip line.

C. Temporary fences or barricades shall be installed to protect trees and plants in areas subject to traffic.

D. Fires shall not be permitted.

E. Within the limits of the Work, water trees and plants that are to remain, in order to maintain their health during construction operations.

F. Cover all exposed roots with burlap which shall be kept continuously wet. Cover all exposed roots with earth as soon as possible. Protect root systems from mechanical damage and damage by erosion, flooding, run-off or noxious materials in solution.

G. If branches or trunks are damaged, prune branches immediately and protect the cut or damaged areas with emulsified asphalt compounded specifically for horticultural use in a manner approved by the ENGINEER.

H. All damaged trees and plants that die or suffer permanent injury shall be removed and disposed of off-site when ordered by the ENGINEER and replaced by a specimen of equal or better quality.

Coordinate Work in this Section with requirements of Section 02220, Demolition, Section 02230, Clearing, and Section 02901, Landscaping.

J. Erect and maintain temporary construction fencing as required to protect area from construction traffic and activities.

1.4 PROTECTION OF EXISTING STRUCTURES

A. Underground Structures:
   1. Underground structures are defined to include, but are not limited to, all sewer, water, gas, and other piping, and manholes, chambers, electrical conduits, tunnels and other existing subsurface work located within or adjacent to the limits of the Work.
   2. All underground structures known to ENGINEER, except water, gas, sewer, electric, and telephone service connections, are shown. This information is shown for the assistance of CONTRACTOR, in accordance with the best information available, but is not guaranteed to be correct or complete.
   3. Explore ahead of trenching and excavation Work and shall uncover all obstructing underground structures sufficiently to determine their location, to prevent damage to them and to prevent interruption to the services which such structures provide. If CONTRACTOR damages an underground structure, he shall restore it to original condition at his expense.
   4. Necessary changes in the location of the Work may be made by ENGINEER to avoid unanticipated underground structures.
   5. If permanent relocation of an existing underground structure or other subsurface facility is required and is not otherwise provided for in the Contract Documents, ENGINEER will direct CONTRACTOR, in writing, to perform the Work, which shall be paid for under the provisions of the General Conditions.

B. Surface Structures:
   1. Surface structures are defined as all existing buildings, structures and other facilities above the ground surface. Included with such structures are their foundations or any extension below the surface. Surface structures include, but are not limited to, buildings, tanks, walls, bridges, roads, dams, channels, open drainage, piping, poles, wires, posts, signs, markers, curbs, walks and all other facilities that are visible above the ground surface.

C. Protection of Underground and Surface Structures:
   1. Sustain in their places and protect from direct or indirect injury all underground and surface structures located within or adjacent to the limits of the Work. Such sustaining and supporting shall be done carefully and as required by the party owning or controlling such structure. Before proceeding with the Work of sustaining and supporting such structure, satisfy the ENGINEER that the methods and procedures to be used have been approved by the party owning same.
   2. Assume all risks attending the presence or proximity of all underground and surface structures within or adjacent to the limits of the Work. Be responsible for all damage and expense for direct or indirect injury caused by his Work to any structure. Repair immediately all damage caused by his Work, to the satisfaction of the owner of the damaged structure.

D. All other existing surface facilities, including but not limited to, guard rails, posts, guard cables, signs, poles, markers, and curbs, which are temporarily removed to facilitate installation of the Work, shall be replaced and restored to their original condition at CONTRACTOR'S expense.

1.5 PROTECTION OF FLOORS AND ROOFS

A. Protect floors and roofs during entire construction period.

B. Proper protective covering shall be used when moving heavy equipment, handling materials or other loads, when painting, handling mortar and grout and when cleaning walls and ceilings.

C. Use metal pans to collect all oil and cuttings from pipe, conduit, or rod threading machines and under all metal cutting machines.

D. Concrete floors less than 28 days old shall not be loaded without written permission of the ENGINEER. No floor, roof or slab shall be loaded in excess of its design loading.

E. Roofs shall not be loaded without written permission of the ENGINEER.

F. Restrict access to roofs and keep clear of existing roofs, except as required by the Work.

G. If access to roofs is required, roofing, parapets, openings and all other construction on or adjacent to roof shall be protected with suitable plywood or other approved means.

1.6 PROTECTION OF INSTALLED PRODUCTS AND LANDSCAPING

A. Provide protection of installed products to prevent damage from subsequent operations. Remove protection facilities when no longer needed prior to completion of Work.

B. Control traffic to prevent damage to equipment, materials and surfaces.

C. Provide coverings to protect equipment and materials from damage.
   1. Cover projections, wall corners and jambs, sills and soffits of openings, in areas used for traffic and for passage of products in subsequent work.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 01722

FIELD ENGINEERING

PART 1 - GENERAL

1.1 DESCRIPTION

A. The ENGINEER will establish a base line for the Project and two benchmarks for use by CONTRACTOR. The ENGINEER and CONTRACTOR will coordinate the location of the benchmarks and base line to suit the Work.

B. CONTRACTOR:
   1. Provide civil, structural and other professional engineering services specified, or required to execute CONTRACTOR'S construction methods.
   2. Develop and make all detail surveys and measurements needed for construction including slope stakes, batter boards, and all other working lines, elevations and cut sheets.
   3. Provide all material required for bench marks, control points, batter boards, grade stakes, structure and pipeline elevation stakes, and other items.
   4. Be solely responsible for all locations, dimensions and levels. No data other than written orders of the ENGINEER shall justify departure from the dimensions and levels required by the Contract Documents.
   5. Safeguard all points, stakes, grade marks, monuments and bench marks made or established on the Work. Re-establish same with the exception of primary control monuments if disturbed and rectify all Work improperly installed because of not maintaining, not protecting or removing without authorization established points, stakes, marks and monuments.
   6. Provide such facilities and assistance as may be necessary for ENGINEER to check line and grade points placed by CONTRACTOR. Do not perform any excavation or embankment work until all cross-sectioning necessary for determining pay quantities has been completed and checked by ENGINEER.
   7. CONTRACTOR shall provide notices and comply with all laws, ordinances, rules and regulations bearing on the conduct of the Work. If CONTRACTOR observes that the Contract Documents are at variance therewith, promptly notify the ENGINEER, in writing.

1.2 CONTRACTOR'S FIELD ENGINEER

A. Employ and retain at the site of the Work a field engineer with the experience and capability of performing all engineering tasks required of CONTRACTOR. Tasks included are:

1. Provide daily reports of Project activity. Reports to be submitted to the ENGINEER with all pertinent information pertaining to the project as follows:
   a. Number of employees.
   b. Subcontractor employees.
   c. Breakdown of employees by trades.
   d. Major equipment and materials installed.
   e. Major construction equipment utilized.
   f. Location of all areas in which construction was done.
   g. Materials and equipment received.
   h. Work and tests performed.
   i. Weather conditions.
   j. Safety.
   k. Delays.
   l. Instructions received.
2. Submit two copies of CONTRACTOR'S daily reports. The daily report is due at the ENGINEER'S field office by 9:00 a.m. the next working day after the Work was performed and shall be signed by a responsible member of CONTRACTOR'S staff.
3. Check all formwork, reinforcing, inserts, structural steel, bolts, sleeves, piping, other materials and equipment.
4. Maintain field office files and drawings, Record Drawings, and coordinate engineering services with subcontractors. Prepare layout and coordination drawings for construction operations.
5. Check and coordinate Work for conflicts and interferences and immediately advise ENGINEER of all discrepancies noted.
6. Cooperate with ENGINEER in field inspections, as required.
7. Review and coordinate Shop Drawings and other submittals.

1.3 CONTRACTOR'S SURVEYOR

A. Employ and retain, as needed, at the Work site a surveyor with the experience and capability of performing all surveyor and layout tasks required of CONTRACTOR. The surveyor shall be a land surveyor registered in the State of Arizona. Tasks included are:
   1. Provide all surveying equipment required including transit, level, stakes and required surveying accessories.
   2. Furnish all required lines and grades for construction of all facilities, structures, pipelines and site improvements.
   3. Keep professional, accurate, well organized, and legible notes of all measurements and calculations made while surveying and laying out the Work.
   4. Survey, locate, and record and redline Drawings to accurately represent all utilities and buried structures prior to backfilling.

B. Any primary control survey monuments damaged or destroyed, will be re-established by the ENGINEER, at CONTRACTOR'S expense.

C. Perform such surveys and computations as are necessary to determine quantities of Work performed or placed during each progress payment period, and shall perform all surveys necessary for the ENGINEER to determine final quantities of Work in place.

D. Notify the ENGINEER at least 24 hours before performing a quantity survey and, unless waived in writing by the ENGINEER, quantity surveys shall be performed in the presence of the ENGINEER.

E. From established primary control points, establish all lines and grades, and elevations necessary to control the Work, and shall be responsible for all measurements that may be required for execution of the Work to the tolerances prescribed in the Contract Documents.

F. Establish, place, and replace as required, such additional stakes, markers, and other controls as may be necessary for control, intermediate checks, and guidance of construction operations.

1.4 SURVEYING

A. Follow the following construction surveying guidelines for this project:
   1. Alignment Staking: Each 50 feet on tangent; each 25 feet on curves.
   2. Slope Staking: Each 50 feet on tangent; each 25 feet on curves; restake every 10 feet in elevation.
   3. Structure: Stake out structures, including elevations; checkouts prior to and during construction.
   4. Pipeline: Stake out pipelines including elevations; checkout prior to and during construction.
   5. Road: Tops each 50 feet on tangent and each 25 feet on curves.
   6. Cross-Section: Original, final and intermediate as required, for the structure sites and other locations as necessary for quantity surveys.
   7. Easement Staking: Each 50 feet on tangent; each 25 feet on curves. Also wooden laths with flagging at 100 feet maximum spacing.
   8. Record Staking: Provide permanent stake where blind flanges or caps are provided for future connecting, with a material acceptable to the ENGINEER.

B. Temporary survey references set by CONTRACTOR for CONTRACTOR'S own use shall be established to at least second order accuracy (e.g., 1:10000). Construction staking used as a guide for the actual Work shall be set at least third order accuracy (e.g., 1:5000). The basis on which such orders are established shall be sufficient to provide the absolute margin for error specified below.

C. The horizontal accuracy of easement staking shall be plus or minus 0.1 feet. The accuracy of all other staking shall be plus or minus 0.04 feet horizontally and plus or minus 0.02 feet vertically.

D. Survey calculations shall include an error analysis sufficient to demonstrate the required accuracy.

E. Survey Records:
   1. Maintain a complete, accurate log of all control and survey Work as it progresses.
   2. All survey data shall be in accordance with recognized professional surveying standards. All original field notes, computations, and other surveying data shall be recorded by CONTRACTOR'S surveyor in CONTRACTOR furnished hard-bound field books, and shall be signed and sealed by CONTRACTOR'S surveyor. The completeness and accuracy of all survey Work, and the completeness and accuracy of the survey records, including the field books, shall be the responsibility of CONTRACTOR. Failure to organize and maintain survey records in a professional manner to allow reasonable and independent verification of all calculations by the ENGINEER, and to allow reasonable identification by the ENGINEER of all elevations, dimensions, and grades of the Work shall be cause for rejection of the survey records, including the field books.
   3. Illegible notes or data, or erasures on any page of the field books is not acceptable. Copied notes or data shall not be permitted. Corrections by ruling or lining out errors will be satisfactory only if initialed by the surveyor. Violation of the above may require resurveying the data in question.

F. Survey Submittal:
   1. Survey submittal shall be made as described herein. Submittal shall be signed and sealed by CONTRACTOR'S surveyor and shall include:
      a. A complete survey plan that shall be submitted ten days prior to beginning survey Work.
      b. Resumes shall be submitted of the Registered Land Surveyors conducting the Work ten days prior to beginning survey Work. During the course of the Work, a resume shall be submitted for each new Registered Land Surveyor working on the project at least ten days prior to the beginning of Work by such new Registered Land Surveyor.
      c. A sample of the proposed survey field books to be maintained by CONTRACTOR'S surveyor. The sample shall have sufficient information and detail, including example calculations and notes, to demonstrate that the field books will be organized and maintained in a professional manner, meeting the requirements of Article 1.3 and Article 1.4 of this Section.
      d. The original field books shall be submitted within two days upon completion of the Work.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION) + +

SECTION 01723

CUTTING AND PATCHING

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section includes administrative and procedural requirements for the cutting and coring, and rough and finish patching of holes and openings in existing construction.

B. All cutting, coring and rough patching shall be performed by CONTRACTOR requiring the opening. Finish patching shall be the responsibility of CONTRACTOR and shall be performed by the trade associated with the application of the particular finish.

C. Provide cutting, coring, fitting and patching, including attendant excavation and backfill required to complete the Work, or to:
   1. Remove and replace defective Work or Work not conforming to requirements of the Contract Documents.
   2. Remove samples of installed Work as specified or required for testing.
   3. Remove all constructions required to provide for specified alterations or addition to existing work.
   4. Uncover Work to provide for ENGINEER'S observation of covered Work or observation by regulatory agencies having jurisdiction.
   5. Connect to completed Work that was not accomplished in the proper sequence.
   6. Remove or relocate existing utilities and pipes that obstruct the Work in locations where connections must be made.
   7. Make connections or alterations to existing or new facilities.

D. Coordinate the requirements of the Work in this Section along with the requirements of the Sections listed below which includes Work that is directly related to this Section.
   1. Division 2, Site Work, through 17, Instrumentation, Sections for specific requirements and limitations applicable to cutting and patching individual parts of the Work.

1.2 QUALITY ASSURANCE

A. Structural Work: Do not cut or patch structural elements in a manner that would change their load-carrying capacity as load-deflection ratio.

B. Operating Elements: Do not cut or patch operating elements in a manner that would result in reducing their capacity to perform as intended. Do not cut or patch

operating elements or related components in a manner that would result in increased maintenance or decreased operational life or safety.

1.3 SUBMITTALS

A. Submit a written request to ENGINEER well in advance of executing any cutting or alteration which affects:
   1. Design function or intent of Project.
   2. Work of OWNER or any other contractor.
   3. Structural value or integrity of any element of the Project.
   4. Integrity or effectiveness of weather-exposed or moisture-resistant elements or systems.
   5. Efficiency, operational life, maintenance or safety of operational elements.
   6. Visual qualities of sight-exposed elements.

B. Request shall include:
   1. Identification of Project.
   2. Description of affected Work of CONTRACTOR and work of others.
   3. Necessity for cutting.
   4. Effect on work of OWNER or any other contractor, or on structural or weatherproof integrity of Project.
   5. Description of proposed Work, describing:
      a. Scope of cutting and patching.
      b. Trades who will be executing the Work.
      c. Products proposed to be used.
      d. Extent of refinishing.
      e. Schedule of operations.
   6. Alternatives to cutting and patching, if any.
   7. Designation of party responsible for cost of cutting and patching, when applicable.
   8. Written permission of any other contractor whose work will be affected.

C. Should conditions of Work, or schedule, indicate a change of materials or methods, submit written recommendation to ENGINEER, including:
   1. Conditions indicating change.
   2. Recommendations for alternative materials or methods.
   3. Submittals as required for substitutions.

D. Submit written notice to ENGINEER, designating time Work will be uncovered, to provide for observation. Do not begin cutting or patching operations until authorized by ENGINEER.

E. Conform to all applicable specifications for application and installation of materials used for patching.

1.4 WARRANTY

A. Replace, patch and repair materials and surfaces cut or damaged during cutting and patching operations, by methods and with materials in such a manner as to not void required or existing warranties.

PART 2 - PRODUCTS

2.1 MATERIALS, GENERAL

A. Use materials identical to existing materials. For exposed surfaces, use materials that visually match existing adjacent surfaces to fullest extent possible. If identical materials are unavailable or cannot be used, use materials whose installed performance will equal or surpass that of existing materials.

PART 3 - EXECUTION

3.1 GENERAL

A. Perform all cutting and coring in such a manner as to limit the extent of patching.

B. Core drill all holes to be cut through concrete and masonry walls, slabs or arches, unless otherwise approved by the ENGINEER.

3.2 INSPECTION

A. Examine surfaces to be cut and patched and conditions under which cutting and patching are to be performed before cutting.

B. Report unsatisfactory or questionable conditions to ENGINEER, in writing. Do not proceed with Work until the ENGINEER has provided further instructions.

3.3 PREPARATION

A. Provide temporary support as required to maintain structural integrity of Project, to protect adjacent Work from damage during cutting, and to support the Work to be cut.

B. Protect existing construction during cutting and patching to prevent damage. Provide protection from adverse weather conditions for portions of the Project that will be exposed during cutting and patching operations.
   1. Avoid interference with use of adjoining areas or interruption of free passage to adjoining areas.

2. Do not cut existing pipe, conduit or ductwork serving facilities scheduled to be removed or relocated until provisions have been made to bypass them.

3.4 CORING

A. Perform coring with a non-impact rotary tool using diamond core drills. Size holes for pipe, conduit, sleeves, equipment or mechanical seals, as required.

B. Protect existing equipment, utilities and adjacent areas from water and other damage covered by drilling operations.

C. Vacuum or otherwise remove slurry or tailings from the Work area following drilling.

3.5 CUTTING

A. Cut existing construction using methods least likely to damage elements retained or adjoining construction and that will provide proper surfaces to receive installation or repair.
   1. In general, use hand or small power tools designed for sawing or grinding, not hammering and chopping.
   2. Cut through concrete and masonry using a concrete wall saw with diamond saw blades.
      a. Provide for control, on both sides of walls, of slurry generated by sawing.

B. Cut holes and slots as small as possible, neatly to size required, and with minimum disturbance of adjacent surfaces. Provide temporary covering over openings where not in use.

C. To avoid marring existing finished surfaces, cut or drill from exposed or finished side into concealed side.

D. Provide adequate bracing of area to be cut prior to start of cutting.

E. Provide equipment of adequate size to remove cut panel.

3.6 PATCHING

A. Patch construction by filling, repairing, refinishing, closing-up and similar operations following performance of other Work. Patch with durable seams that are as invisible as possible. Provide materials and comply with installation requirements specified, in other Sections of these Specifications.

B. Where feasible, test patched areas to demonstrate integrity of installation.

C. Fit Work airtight to pipes, sleeves, ducts, conduit and other penetrations through surfaces.

D. Restore exposed finishes of patched areas and extend finish restoration into retained adjoining construction in a manner that will eliminate evidence of patching and refinishing.
   1. For continuous surfaces, refinish to nearest intersection.
   2. For an assembly, refinish entire unit.

E. Patch, repair or rehang existing ceilings as necessary to provide an even-plane surface of uniform appearance.

3.7 CLEANING

A. Clean areas and spaces where cutting, coring and patching are performed. Clean piping, conduit or similar constructions before applying paint or other finishing materials. Restore damaged pipe covering to original condition.

+ + END OF SECTION + +

SECTION 01724

CONNECTIONS TO EXISTING FACILITIES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Perform all construction necessary to complete connections and tie-ins to existing facilities.

B. Keep existing facilities in operation unless otherwise specifically permitted in these Specifications or approved by OWNER.

C. Perform all construction activities so as to avoid interference with operations of the facility and the work of others.

1.2 BYPASSING

A. Bypassing of plant flow will be permitted only for brief intermittent periods necessary to make the connections, as described in Section 02145 – Diversion of Water or Sewage Flow and Dewatering.

1.3 SEQUENCING AND OPERATIONS

A. All operations of existing valves and gates required for the Work shall be done by OWNER.

B. Insofar as possible, all equipment shall be tested and in operating condition before the final tie-ins are made to connect equipment to the existing facility.

C. Carefully coordinate all Work and schedules and shall provide OWNER written notice at least (--1--) hours before shut-downs or by-passes are required.

D. Work Sequence: Sequence of Work and Schedule of Completion is specified under Section 01111-Schedule of Completion, Section 01140 – Work Restrictions, Section 01143 - Coordination with OWNER'S Operations, and shown on the Construction Sequence Diagrams included in the Drawings.

1.4 ELECTRICAL INSTALLATION

A. Electrical shutdowns are generally not permitted only. If the CONTRACTOR determines that an electrical shutdown is required then a detailed shutdown sequence must be submitted in writing and approved by the ENGINEER and OWNER. Also, any shutdown will require the CONTRACTOR to schedule the

shutdown based on minimum flows based on the time of day and seasonal weather variations as determined by the OWNER. See also constraints indicated in Section 02145 – Diversion of Water or Sewage Flow and Dewatering.

1.5 SUBMITTALS

A. For any tie-ins/connections or required shutdowns to existing mains and systems, the CONTRACTOR shall submit a shutdown/tie-in plan to Water Distribution personnel and Engineering and shall be approved at least two weeks prior to the start of the event. The plan shall include dates, durations, procedures, staffing, and any other information pertinent to shutting down the system and connecting to a new system.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 01731

INSTALLATION DATA

PART 1 - GENERAL

1.1 DESCRIPTION

A. Installation data is defined as written instructions; drawings; illustrative, wiring and schematic diagrams; diagrams identifying external connections, terminal block numbers and internal wiring; and all other such information pertaining to installation of materials and equipment that is not furnished with Shop Drawings. Included are all printed manufacturers installation instructions, including those that may be attached to equipment and for which approval by the ENGINEER is not required.

1.2 SUBMITTALS

A. Submit four copies of all such data to the ENGINEER for each piece of equipment which he furnishes and for all other construction products for which such information is available from manufacturer. Data shall be acceptably identified and accompanied with a letter of transmittal. Three copies shall be transmitted to the ENGINEER, in accordance with Section 01332 - Shop Drawing Procedures, and one copy shall be transmitted to the ENGINEER at the Engineer's Field office. Copies shall be transmitted at least two weeks prior to the start of the equipment installation.

B. A copy of the installation data shall be provided in each copy of the Operation and Maintenance Manuals for the covered materials and equipment.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 01740

CLEANING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Execute cleaning, during progress of the Work, at completion of the Work, and as required by General Conditions. If CONTRACTOR fails to clean areas as specified in this Section, the OWNER will have the areas cleaned and backcharge CONTRACTOR.

1.2 REQUIREMENTS OF REGULATORY AGENCIES:

A. In addition to the requirements herein, maintain the cleanliness of the Work and surrounding premises within the Work limits so as to comply with federal, state, and local fire and safety laws, ordinances, codes and regulations.

B. Comply with all federal, state and local anti-pollution laws, ordinances, codes and regulations when disposing of waste materials, debris and rubbish.

1.3 PROGRESS CLEANING:

A. General: Clean the Site, Work areas and other areas CONTRACTOR is permitted to occupy by Laws and Regulations at least weekly. Dispose of materials lawfully according to Laws and Regulations:
   1. Comply with requirements in NFPA 241, Standard for Safeguarding Construction, Alteration and Demolition Operations, for removal of combustible waste materials and debris.
   2. Do not hold other materials more than three days if the temperature is expected to rise above 80° F.
   3. Provide suitable containers for storage of waste materials and debris.
   4. Containerize hazardous and unsanitary waste materials separately from other waste. Mark containers appropriately.

B. Project:
   1. Maintain Project free of waste materials and debris.
   2. Keep exterior dust generating areas wetted down.
   3. Paved roads: Comply with the requirements of Section 01550 – Access Roads and Parking Areas.

C. Work Areas: Clean areas where Work is in progress to the level of cleanliness necessary for proper execution of the Work.
   1. Remove liquid spills promptly and report spills to the OWNER and ENGINEER immediately.

2. Where dust would impair proper execution of the Work, broom-clean or vacuum the entire Work area, as appropriate.

D. Installed Work: Keep installed Work clean. Clean installed surfaces according to written instructions of manufacturer or fabricator of product installed, using only cleaning materials specifically recommended. If specific cleaning materials are not recommended, use cleaning materials that are not hazardous to health or property and that will not damage exposed surfaces.

E. Concealed Spaces: Remove all debris from concealed spaces before enclosing the space.

F. Exposed Surfaces: Clean exposed surfaces and protect as necessary to ensure freedom from damage and deterioration at time of Substantial Completion.

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

H. Waste Disposal:
1. Properly dispose of all waste materials, surplus materials, debris and rubbish off the Project site.
2. Do not burn or bury rubbish and waste materials on the Project site.
3. Do not dispose of volatile or hazardous wastes such as mineral spirits, oil, or paint thinner in storm or sanitary drains.
4. Do not discharge wastes into streams or waterways.
5. Sole responsibility for complying with any federal, state, and local environmental and regulations in disposing of waste, belongs to CONTRACTOR.

I. During handling and installation, clean and protect construction in progress and adjoining materials already in place. Apply protective covering where required to ensure protection from damage or deterioration at Substantial Completion.

J. Clean and provide maintenance on completed construction as frequently as necessary through the remainder of the construction period. Adjust and lubricate operable components to ensure operability without damaging effects.

1.4 FINAL CLEANING

A. General: Provide final cleaning.
   1. Complete the following cleaning and waste-removal operations before requesting inspection for certification of Substantial Completion for entire Project or for a portion of Project:
      a. Clean and remove from the Project rubbish, waste material, debris, and other foreign substances.
      b. Mechanical sweeping of paved areas. Remove petrochemical spills, stains, and other foreign deposits.
      c. Hose clean sidewalks and loading areas.
      d. Rake grounds that are neither planted nor paved to a smooth, even-textured surface.
      e. Leave water courses, gutters, and ditches open and clean.
      f. Repair pavement, roads, sod, and all other areas affected by construction operations and restore them to original condition or to minimum condition specified.
      g. Clean exposed exterior and interior hard-surfaced finishes to a dirt-free condition, free of spatter, grease, stains, fingerprints, films, and similar foreign substances.
      h. Clean, wax and polish wood, vinyl and painted floors.
      i. Remove debris and surface dust from limited access spaces, including roofs, plenums, shafts, trenches, equipment vaults, manholes, and similar spaces.
      j. Sweep concrete floors broom clean in unoccupied spaces.
      k. Clean transparent materials, including mirrors and glass in doors and windows. Remove glazing compounds and other noticeable, vision-obscuring materials. Replace chipped or broken glass and other damaged transparent materials.
      l. Remove tags and labels that are not permanent.
      m. Touch up and otherwise repair and restore chipped, scratched, dented or otherwise marred surfaces to specified finish and match adjacent surfaces.
         1) Do not paint over “UL” or similar labels, including manufacturer mechanical and electrical nameplates.
      n. Wipe surfaces of mechanical and electrical equipment, and similar equipment. Remove excess lubrication, paint and mortar droppings, and other foreign substances.
      o. Clean plumbing fixtures to a sanitary condition, free of stains, including stains resulting from water exposure.
      p. Replace disposable air filters and clean permanent air filters. Clean exposed surfaces of diffusers, registers, and grills.
      q. Clean light fixtures, lamps, globes, and reflectors to function with full efficiency. Replace burned-out bulbs, and those noticeably dimmed by hours of use, and defective and noisy starters in fluorescent and mercury vapor fixtures to comply with requirements for new fixtures.

r. Maintain the cleaning until OWNER occupies the Project or portion thereof.
s. Leave Project clean and in a neat and orderly condition satisfactory to ENGINEER.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 01751

STARTING AND PLACING EQUIPMENT IN OPERATION

PART 1 - GENERAL

1.1 DESCRIPTION

A. Initially start-up and place all equipment installed into successful operation according to manufacturer's written instructions and as instructed by manufacturer's field representative. Provide all material, labor, tools, equipment, chemicals, lubricants, and expendables required to complete start-up.

B. No system or subsystem shall be started up for continuous operation unless all components of that system or subsystem, including instrumentation, have been tested and proven to be operable as intended by the Contract Documents.

C. General Activities Include:
   1. Cleaning.
   2. Removing temporary protective coatings.
   3. Flushing and replacing greases and lubricants, where required by manufacturer.
   4. Lubrication.
   5. Check shaft and coupling alignments and reset where needed.
   6. Check and set motor, pump and other equipment rotation, safety interlocks, and belt tensions.
   7. Check and correct if necessary leveling plates, grout, bearing plates, anchor bolts, fasteners, and alignment of piping which may put stress on pumping equipment connected to it.
   8. All adjustments required.

D. Provide chemicals and lubricants and all other required operating fluids.

E. Provide fuel, electricity, water, filters, and other expendables required for start-up of equipment, unless otherwise specified.

F. OWNER provide sufficient personnel to assist CONTRACTOR in the start-up, but the prime responsibility for proper mechanical operation shall belong to CONTRACTOR. Manufacturer's representatives shall be present during initial start-up and operation, unless otherwise acceptable to ENGINEER.

G. Start-up of either the heating or air conditioning systems is dependent upon the time of year that the plant start-up is initiated. CONTRACTOR make arrangements with OWNER to return at the beginning of the next heating or air conditioning season (whichever is applicable) to start the appropriate system.

H. No system, unit process or any piece of equipment shall be started up for continuous operation without the approved Operation and Maintenance Manuals being turned over to the OWNER.

I. Training shall be provided prior to turning the operation of a system, unit process or piece of equipment over to the OWNER. Training shall be scheduled for each plant staff work shift accordingly. Training shall conform to the requirements of Section 01821, Instruction of Operations and Maintenance Personnel.

J. Completion of start-up shall be when the OWNER assumes responsibility for operation of the equipment. If the OWNER does not assume operational responsibility and in the opinion of the ENGINEER start-up tasks are completed, the ENGINEER will notify CONTRACTOR, in writing, of the completion of the start-up period.

1.2 MINIMUM START-UP REQUIREMENTS

A. Bearings and Shafting:
1. Inspect for cleanliness, and clean and remove all foreign materials.
2. Verify alignment.
3. Replace defective bearings and those which run rough or noisy.
4. Grease as necessary and in accord with manufacturer's recommendations.

B. Drives:
1. Adjust tension in V-belt drives, and adjust varipitch sheaves and drives for proper equipment speed.
2. Adjust drives for alignment of sheaves and V-belts.
3. Clean and remove foreign materials before starting operation.

C. Motors:
1. Check each motor for comparison to amperage manufacturer nameplate value.
2. Correct conditions which produce excessive current flow and exist due to equipment malfunction.

D. Pumps:
1. Check glands and seals for cleanliness and adjustment before running pump.
2. Inspect shaft sleeves for scoring.
3. Inspect mechanical faces, chambers, and seal rings, and replace if defective.
4. Verify that piping system is free of dirt and scale before circulating liquid through the pump.

E. Valves:
1. Inspect both hand and automatic control valves, and clean bonnets and stems.
2. Tighten packing glands to assure no leakage, but permit valve stems to operate without galling.

3. Replace packing in valves to retain maximum adjustment after system is determined to be complete.
4. Replace packing on any valve that continues to leak.
5. Remove and repair bonnets that leak.
6. Coat packing gland threads and valve stems with a surface preparation of "Moly-Cote" or "Fel-Pro" after cleaning.

F. Verify that control valve seats are free from foreign material and are properly positioned for intended service.

G. Tighten flanges and all other pipe joints after system has been placed in operation.
1. Replace gaskets which show any sign of leakage after tightening.

H. Inspect all joints for leakage.
1. Promptly remake each joint that appears to be faulty; do not wait for rust to form.
2. Clean threads on both parts, and apply compound and remake joints.

I. After system has been placed in operation, clean strainers, drives, pockets, orifices, valve seats and headers in fluid system to assure freedom from foreign materials.

J. Open steam traps and air vents, where used, and remove operating elements.
1. Clean thoroughly, replace internal parts and put back into operation.

K. Remove rust, scale and foreign materials from equipment and renew defaced surfaces.

L. Set and calibrate draft gages of air filters and other equipment.

M. Inspect fan wheels for clearance and balance.
1. Provide factory-authorized personnel for adjustment when needed.

N. Check each electrical control circuit to assure that operation complies with Specifications and requirements and to provide desired performance.

O. Inspect each pressure gage and thermometer for calibration.
1. Replace items which are defaced, broken, or which read incorrectly.

P. Repair any damaged insulation.

Q. Vent gasses trapped in any part of systems.
1. Verify that liquids are drained from all parts of gas or air systems.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 01752

EQUIPMENT AND SYSTEM
STARTUP AND PERFORMANCE TESTING

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section contains requirements for CONTRACTOR'S performance in documenting testing Work required under this Contract. In addition, this Section contains requirements for CONTRACTOR'S performance testing during installed startup and performance testing of all mechanical, electrical, instrumentation, and HVAC equipment and systems. This Section supplements, but does not supersede specific testing requirements, found elsewhere in the Contract Documents.

B. Upon completion of design, CONTRACTOR and ENGINEER shall submit a testing, startup and commissioning plan, and schedule to the OWNER for review and approval prior to any system or equipment startup. There shall be at a minimum two 4-hour work sessions to work through the development of a thorough testing plan. A draft testing, startup and commissioning plan shall be submitted to the OWNER and ENGINEER for review and comment at 30 percent of project construction. A revised draft of the plan shall be submitted to the OWNER and ENGINEER for review and comment at 60 percent of project construction. A final plan shall be submitted at 90 percent of project construction.

C. Refer to the City of Phoenix Equipment Setup / System Testing Guidance Manual (Guidance Manual) to assist in development of a testing program that will fulfill the requirements of the specifications.

1.2 QUALITY ASSURANCE

A. CONTRACTOR'S Quality Assurance Manager: Appoint an operations engineer or equally qualified operations specialist as Quality Assurance Manager to manage, coordinate, and supervise CONTRACTOR'S Quality Assurance Program. The Quality Assurance Manager shall have at least five years of total experience, or experience on at least five separate projects, in managing the startup and performance testing of mechanical, electrical, instrumentation, HVAC, and piping systems. Operations engineers shall be graduates from a minimum four year course in mechanical or civil engineering. Operations specialists shall have equivalent experience in plant operation and maintenance. The quality assurance program shall include:
   1. A testing plan setting forth the sequence in which all testing Work required under the Contract Documents will be implemented.

2. A documentation program to record the results of all equipment and system tests.
3. An installed startup and performance testing program for all mechanical, electrical, instrumentation, and HVAC equipment and systems installed under this Contract.
4. A calibration program for all instruments, meters, monitors, gages, and thermometers installed under this Contract.
5. A calibration program for all instruments, gages, meters, and thermometers used for determining the performance of equipment and systems installed under this Contract.
6. A testing schedule conforming to the requirements specified in Paragraph 2.2 C., below.

B. For the purposes of this Section, a system shall include all required items of equipment, devices and appurtenances connected in such a fashion as their operation or function complements, protects or controls the operation or function of the others. The Quality Assurance Manager shall coordinate the activities of all subcontractors and suppliers to implement the requirements of this Section.

C. Calibration:
1. All test equipment (gages, meters, thermometers, analysis instruments, and other equipment) used for calibrating or verifying the performance of equipment installed under this Contract shall be calibrated and certified to within plus or minus two percent of actual value at full scale. Test equipment employed for individual test runs shall be selected so that expected values as indicated by the detailed performance specifications will fall between 60 and 85 percent of full scale. Pressure gages shall be calibrated in accordance with ANSI/ASME B40.1. Thermometers shall be calibrated in accordance with ASTM E77 and shall be furnished with a certified calibration curve.
2. Liquid flow meters, including meters installed in pipelines with diameters greater than 2-inches shall be calibrated insitu using either the total count or dye dilution methods, as approved by the ENGINEER. Gas flow meters installed in piping systems with diameters greater than 6-inches shall be calibrated insitu using the pitot tube velocity averaging method. Flow meter calibration work shall be performed by individuals skilled in the techniques to be employed. Calibration tests for flow metering systems shall be performed over a range of not less than 10 percent to at least 75 percent of system full scale. At least five confirmed valid data points shall be obtained within this range. Confirmed data points shall be validated by not less than three test runs with results which agree within plus or minus two percent.

D. References:
1. This Section contains references to the following documents. They are a part of this Section as specified and modified. In case of conflict between the

requirements of this Section and those of the listed documents, the requirements of this Section shall prevail.

2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid. If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, whether or not the document has been superseded by a version with a later date, discontinued or replaced.
3. Equipment Setup / System Testing Guidance Manual should be used as a resource to assist with understanding the detail the OWNER is requiring to ensure all equipment and systems are operational with respect to the contract documents. The Guidance Manual shows how to assemble a systematic equipment and system testing program that will satisfy the contract requirement. The Guidance Manual shall be used as a tool to assist the development of an equipment setup, testing plans, and documentation binder. The Guidance Manual is not all encompassing requirements. Meaning there are project specification and equipment specific requirement that will need to be added to the document; plus modification to the type of project, refer to project specifications for additional information.

Reference	Title
ANSI/ASME B40.1	Gauges Pressure Indicating Dial Type--Elastic Element
ASTM E77	Method for Verification and Calibration of Liquid-in-Glass Thermometers
ASHRAE 41.8	Standard Methods of Measurement of Flow of Gas
City of Phoenix	Guidance Manual Equipment Setup / System Testing Plan

1.3 SUBMITTALS

A. Submit for approval the following:
   1. A complete description of CONTRACTOR'S plan for documenting the results from the test program in conformance with the requirements of Paragraph 2.2.A., below, including:
      a. Proposed plan for documenting the calibration of all test instruments.

b. Proposed plan for calibration of all instrument systems, including flow /level meters and all temperature, pressure, weight, and analysis systems.
c. Sample forms for documenting the results of field pressure and performance tests. Forms located in Section 01331 – Reference Forms.
d. A list of all CMMS Tag numbers as provided in Section 01630, Computerized Maintenance Management System Tags.

2. The credentials and certification of the testing laboratory proposed by CONTRACTOR for calibration of all test equipment.
3. Pre-startup check out procedures, reviewed and approved by the respective equipment manufacturers.
4. Detailed testing plans, setting forth step-by-step descriptions of the procedures proposed by CONTRACTOR for the systematic startup and performance testing of all equipment and systems installed under this Contract.
5. A schedule and subsequent updates, presenting CONTRACTOR'S plan for startup and performance testing the equipment and systems installed under this Contract.
6. A schedule establishing the expected time period (calendar dates) when CONTRACTOR plans to commence performance testing of the completed systems, along with a description of the temporary systems and installations planned to allow operational testing to take place.
7. A summary of the Quality Assurance Manager's qualifications, conforming to the requirements of Paragraph 1. 2. A, above.
8. All records produced during the startup and testing program.
9. Systems or unit process or any piece of equipment shall not be started up without the approved Operation and Maintenance Manuals being turned over to the OWNER.
10. Written notice to ENGINEER a minimum of 72 hours prior to beginning of any test.

1.4 ADJUSTMENTS

A. Until final tests are completed and approved, make all necessary changes, adjustments and replacements.

PART 2 - PRODUCTS

2.1 GENERAL

A. Prepare test plans and documentation plans as specified in the following paragraphs. The OWNER and ENGINEER will not witness any test work for the purpose of acceptance until all test documentation and calibration plans and the specified system or equipment test plans have been submitted and approved.

2.2 DOCUMENTATION

A. Documentation Plans:
   1. Equipment Setup / System Testing Guidance Manual format shall be used to develop and document test plans.
   2. Develop a records keeping system to document compliance with the requirements of this Section. Calibration documentation shall include identification (by make, manufacturer, model, and serial number) of all test equipment, date of original calibration, subsequent calibrations, calibration method, and test laboratory.
   3. Equipment and system documentation shall include date of test, equipment number or system name, nature of test, test objectives, test results, test instruments employed for the test and signature spaces for the OWNER'S and ENGINEER'S witnesses and CONTRACTOR'S Quality Assurance Manager. A separate file shall be established for each system and item of equipment. These files shall include the following information as a minimum:
      a. Metallurgical tests.
      b. Factory performance tests.
      c. Accelerometer recordings made during shipment.
      d. Field calibration tests[1].
      e. Field pressure tests[1].
      f. Field performance tests[1].
      g. Field operational tests[1].

   ([1]Each of these tests are required even though not specifically noted in detailed specification Section.)
   5. Section 01331, Reference Forms, contains samples showing the format and level of detail required for the documentation forms. These are samples only and are not specific to this Project or to any item of equipment or system to be installed under this Contract. Develop test documentation forms specific to each item of equipment and system installed under this Contract. Acceptable documentation forms for all systems and items of equipment shall be submitted for review by the OWNER and ENGINEER as a condition precedent to CONTRACTOR'S receipt of progress payments in excess of 50 percent of the Contract amount. Once the OWNER and ENGINEER has reviewed and approved the forms proposed by CONTRACTOR, produce sufficient forms, at his expense, to provide documentation of all testing work to be conducted as a part of this Contract.

A. Test Plans:
   1. Develop test plans detailing the coordinated, sequential testing of each item of equipment and system installed under this Contract. Each test plan shall be specific to the item of equipment or system to be tested. Test plans shall identify by specific equipment or CMMS Tag number each device or control station to be manipulated or observed during the test procedure and the specific results to be observed or obtained. Test plans shall also be specific as to

support systems required to complete the test work, temporary systems required during the test work, subcontractors and manufacturers' representatives to be present and expected test duration. As a minimum, the test plans shall include the following features:

a. Step-by-step proving procedure for all control and electrical circuits by imposing low voltage currents and using appropriate indicators to affirm that the circuit is properly identified and connected to the proper device.
b. Calibration of all analysis instruments and control sensors.
c. Performance testing of each individual item of mechanical, electrical, and instrumentation equipment. Performance tests shall be selected to duplicate the operating conditions described in the Contract Documents.
d. System performance tests designed to duplicate, as closely as possible, operating conditions described in the Contract Documents.

2. Test plans shall contain a complete description of the procedures to be employed to achieve the desired test environment.
3. As a condition precedent to receiving progress payments in excess of 75 percent of the Contract amount, or in any event, progress payments due to CONTRACTOR eight weeks in advance of the proposed date the CONTRACTOR intends to begin any testing work (whichever occurs earliest in the Project Schedule), have submitted all test plans required for the systematic field performance and operational tests for all equipment and systems installed under this Contract. Once the ENGINEER has reviewed and approved CONTRACTOR'S test plans, reproduce the plans in sufficient number for CONTRACTOR'S purposes and an additional ten copies for delivery to the ENGINEER. No test work shall begin until CONTRACTOR delivers the specified number of final test plans to the ENGINEER.
4. Test Plans shall be developed and formatted according to the Equipment Setup / System Testing Guidance Manual.

B. Testing Schedule: Provide a startup and testing schedule setting forth the sequence contemplated for performing the test work. The schedule shall be a CPM format, plotted against calendar time, shall detail the equipment and systems to be tested, and shall be coordinated with CONTRACTOR'S Progress Schedule specified in Section 01321 Progress Schedule - CPM. The schedule shall show the contemplated start date, duration of the test and completion of each test. The test schedule shall be submitted no later than four weeks in advance of the date testing is to begin. The ENGINEER will not witness any testing work for the purpose of acceptance until CONTRACTOR has submitted a test schedule and the ENGINEER approves. The test schedule shall be updated weekly, showing actual dates of test work, indicating systems and equipment testing completed satisfactorily and meeting the requirements of the Contract Documents.

C. Binder Format:
1. Prepare data in the format detailed in the forms provided, forms shall be modified with project specific details.

2. Binders: Commercial quality, 8-1/2 inch by 11 inch (size A4), three D side ring binders with durable plastic covers; 2 inch (50 millimeter) maximum ring size. Correlate data into related consistent groupings when multiple binders are used,
3. Cover: Identify each binder with typed project number and name and subject matter of the contents. Titles shall be placed both on the front and binder edge of the binder.
4. Provide tabbed card stock material for each separate section and subsection, with 1/2in extended tabs and typed description on the tabs for the main sections.
5. Text: Printed data or type written data on 20 pound, minimum, white punched paper. Computer generated data shall be printed by letter quality 150 dpi resolution printers unless approved otherwise.
6. Drawings: Provide with reinforced punched binder tab. Bind in with text; Reduce larger drawings and fold to size of text pages but not larger than 11-inches by 17-inches.

2.3 SYSTEM AND EQUIPMENT PERFORMANCE TESTS

A. Each item of mechanical, electrical, instrumentation and HVAC equipment installed under this Contract shall be tested to demonstrate compliance with the performance requirements of the Contract Documents. Each electrical, instrumentation, mechanical, piping, and HVAC system installed or modified under this Contract shall be tested in accordance with the requirements of the Contract Documents.

B. Once all equipment and systems have been tested individually, defined in the Guidance Manual as Contractor Testing. Proceed with performance testing in accordance with the requirements of Article 3.3, below, simulating actual operating conditions to the greatest extent possible. Install temporary connections, bulkheads and make other provisions to recirculate process fluids or otherwise simulate anticipated operating conditions. Performance testing is broken in (2) groups of testing in the Guidance Manual, Verification and Demonstration Testing. During the operational testing period, CONTRACTOR'S Quality Assurance Manager and testing team shall monitor the characteristics of each machine and system and report any unusual conditions to the ENGINEER.

PART 3 - EXECUTION

3.1 GENERAL

A. Quality Assurance Manager: Organize teams made up of qualified representatives of equipment suppliers, subcontractors, CONTRACTOR'S independent testing laboratory, and others, as appropriate, to efficiently and expeditiously calibrate and test the equipment and systems installed and

constructed under this Contract. The objective of the testing program shall be to demonstrate, to the OWNER'S and ENGINEER'S complete satisfaction, that the structures, systems, and equipment constructed and installed under this Contract meets all performance requirements and the facility is Substantially Complete and ready for the commissioning process to commence. In addition, the testing program shall produce baseline-operating conditions for the OWNER to use in a Preventive Maintenance Program.

3.2 CALIBRATION OF FIXED INSTRUMENTS

A. Calibration of analysis instruments, sensors, gages, and meters installed under this Contract shall proceed on a system-by-system basis. No equipment or system performance test shall be performed until all instruments, gages, and meters to be installed in that particular system have been calibrated and the calibration work has been witnessed by the OWNER and ENGINEER.

3.3 EQUIPMENT SETUP / SYSTEM TESTING

A. General:
   1. Supplier Equipment Setup, Calibration, and Checkout: shall consist of but not limited to Pressure or leakage tests ,Electrical testing as specified in Division 16, Electrical, Wiring and piping, individual component, loop, loop commissioning and tuning testing, as specified in Division 17, Instrumentation, Pre-startup check out for all mechanical and HVAC equipment. Pre-startup check out procedures shall be reviewed and accepted by the respective equipment manufacturer. Supplier Equipment Setup, Calibration, and Checkout is further explained in the Guidance Manual.
   2 Contractor testing: shall consists of but not limited to the individual and system tests of all mechanical, electrical, HVAC, and instrumentation equipment and systems shall demonstrate compliance with the performance requirements of the Contract Documents to the CONTRACTOR. Contractor testing is further explained in the Guidance Manual.
   3. Verification Testing: To verify to the Owners Representative that all equipment and systems will function as designed. The Verification Testing is to be designed to duplicate, as closely as possible, the operating design. Verification testing is further explained in the Guidance Manual.
   4. Demonstration Testing: To show the Owner all equipment as a system will function as designed. The testing will simulate various operating conditions to allow the system as a whole to react. The plan will clearly show the system works in various conditions as described in the Control descriptions and detailed in the Process and Instrumentation drawings. Demonstration testing is further explained in the Guidance Manual.

B. Testing for any individual system shall be performed in the order listed above. The order may be altered only on the specific written authorization of the ENGINEER

after receipt of a written request, complete with justification for the change in sequence.

C. Pressure and Leakage Tests: Pressure and leakage tests shall be conducted in accordance with applicable Sections. All acceptance tests shall be witnessed by the ENGINEER. Evidence of successful completion of the pressure and leakage tests shall be the ENGINEER'S signature on the test forms prepared by CONTRACTOR.

D. Equipment Checkout: Prior to energization (in the case of electrical systems and equipment), all circuits shall be rung out and tested for continuity and shielding in accordance with the requirements of Division 16, Electrical.

E. Component Calibration and Loop Testing: Prior to energization (in the case of instrumentation system and equipment), all loops and associated instruments shall be calibrated and tested, as specified in Division 17, Instrumentation.

F. Electrical Resistance: Electrical resistance testing shall be in accordance with the requirements of Division 16, Electrical.

G. Pre-Startup Tests: Pre-startup tests shall include the following:
   1. Alignment of equipment using reverse dial indicator method.
   2. Pre-operation lubrication.
   3. Tests in accordance with the manufacturers' recommendations for pre-start preparation and pre-operational check out procedures.
   4. Pre-Startup tests shall conform to the requirements of Section 01751, Starting and Placing Equipment in Operation.

H. System Performance Tests
   1. System Performance Tests are broken in to (2) groups of tests, Verification and Demonstration testing. Refer to the Guidance Manual for further definition of how to develop System Performance Tests.
   2. General: Once all affected equipment has been subjected to the required pre-operational check out procedures and the ENGINEER has witnessed and has not found deficiencies in that portion of the Work, individual items of equipment and 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.
   3. For each system performance test phase, the equipment shall be operated a sufficient period of time to determine machine operating characteristics, including noise, temperatures and vibration; to observe performance characteristics; and to permit initial adjustment of operating controls and shall last no less than the continuous days indicated in Section 01810 - Commissioning. When testing requires the availability of auxiliary systems such as looped piping, electrical power, compressed air, control air, or

instrumentation which have not yet been placed in service, 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 approval by the OWNER and ENGINEER. During the performance test period, obtain baseline-operating data on all equipment with motors greater than one horsepower to include amperage, bearing temperatures, and vibration. The baseline data shall be collected for the OWNER to enter in a Preventive Maintenance Program.

4. Test results shall be within the tolerances set forth in the detailed specification Sections of the Contract Documents. 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 performance test, any doubt, dispute, or difference should arise between the ENGINEER and 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, 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 CONTRACTOR. Where the results of any performance test fail to comply with the contract requirements for such test, then such repeat tests as may be necessary to achieve the contract requirements shall be made by CONTRACTOR at his expense.
5. Provide, at no expense to the OWNER, all power, fuel, compressed air supplies, water, and chemicals, all labor, temporary piping, heating, ventilating, and air conditioning for any areas where permanent facilities are not complete and operable at the time of functional tests, and all other items and work required to complete the functional tests. Temporary facilities shall be maintained until permanent systems are in service.
6. Should the testing period be halted for any reason, the operational testing program shall be repeated, until the specified continuous period has been accomplished without interruption. All process units shall be brought to full operating conditions, including temperature, pressure, flow and level.
7. Record Documents shall conform to the requirements of Section 01782, Record Documents, of facilities involved shall be accepted and ready for turnover to the OWNER 72 hours prior to operational testing.
8. Phase Retesting: If under test, any portion of the Work should fail to fulfill the Contract requirements and is adjusted, altered, renewed, or replaced, tests on that portion when so adjusted, altered, removed, or replaced, together with all other portions of the Work as are affected thereby, shall, unless otherwise directed by the ENGINEER, be repeated within reasonable time and in accordance with the specified conditions. Pay to the OWNER all reasonable expenses incurred by the OWNER, including the costs of the ENGINEER, as a result of repeating such tests.
9. Post-Test Inspection: Once testing has been completed, all machines shall be rechecked for proper alignment and realigned, as required. 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. Any defects found during the course of the inspection shall be repaired or the specific part or entire equipment item shall be replaced to the complete satisfaction of the ENGINEER, at no additional cost to the OWNER.

10. After the CONTRACTOR has demonstrated and proven to the ENGINEER that all system are functioning properly and has been documented in the approved testing and startup plan, then the CONTRACTOR shall demonstrate this reliability to the OWNER. The OWNER demonstration shall be executed as agreed upon and documented per the approved testing and startup plan.

I. Operational Availability Demonstration, defined as Commissioning in the Guidance Manual.

1. Operational Availability Demonstration (OAD): CONTRACTOR shall complete a 30-day OAD, which shall begin following completion of the integrated system field test as specified above and shall continue until a time frame has been achieved wherein the equipment, instrumentation and control system hardware availability meets or exceeds 99.7 percent for the testing periods indicated in Section 01810 - Commissioning and no system failures have occurred which result in starting the OAD over again. During the OAD the system shall be available to plant operating personnel for use in normal operation of the Plant.
2. For the purpose of the Operational Availability Demonstration, the system shall be defined as consisting of the following systems and components:
   a. Submersible pumps and all associated piping, valves, instruments, variable frequency drives, and associated control systems.
   b. Biofilter odor control system and all associated piping, valves, instruments, exhaust fans, ductwork and associated control systems.
3. The conditions listed below shall constitute system failures which are considered critical to the operability and maintainability of the system. The Operational Availability Demonstration shall be terminated if one or more of these conditions occur. Following correction of the problem, a new 30-day consecutive day OAD shall begin.
   a. Failure to repair a hardware or software problem within 120 consecutive hours from the time of notification of a system failure.
   b. Recurrent hardware problems: If the same type of problem occurs three times or more.
4. The following conditions shall constitute a system failure in determining the system availability based on the equation specified in Paragraph 1.5.E., below
   a. Failure of any equipment, instrument, or automatic control.
   b. Loss of communications between devices on the communications network.
   c. Failure of one or more input/output components.

d. Failures of any type affecting ten or more input/output points simultaneously.
e. Failure of any type affecting one or more regulatory control loops or sequential control strategies thereby causing a loss of the automatic control of the process variable or process sequence operation.
f. Failure of power supply. Where redundant power supplies are provided, failure of one power supply shall not constitute a system failure provided the backup power supply operates properly and maintains supply power. Failure of the backup supply to operate properly and maintain supply power shall constitute a system failure.

5. The system availability shall be calculated based on the following equation:

$$A = \frac{MTBF}{MTBF + MTTR} \times 100\%$$

Where:
A = system availability in percent
MTBF = average time interval between consecutive system failures
MTTR = mean time required to repair system failures

6. Time between failures shall be the period between the time that a reported system failure has been corrected and the time of subsequent notification of CONTRACTOR that another system failure has occurred in terms of operating hours.
7. Time to repair shall be the period between the time that CONTRACTOR is notified of a system failure and the time that the system has been restored to proper operation in terms of hours with an allowance for the following dead times which shall not be counted as part of the time to repair period.
   a. Actual travel time for service personnel to get to the plant site up to a maximum of six hours from the time CONTRACTOR is notified of a system failure.
   b. Time for receipt of spare parts to the plant site once requested up to a maximum of 24 hours. No work shall be done on the system while waiting for delivery of spare parts.
   c. Dead time shall not be counted as part of the system available period. The dead time shall be logged and the duration of the OAD extended for an amount of time equal to the total dead time.
8. Completion of a commissioning period per Section 01810 – Commissioning without any restarts of the OAD and with a system availability in excess of 99.7 percent will constitute acceptance of the System by OWNER.
9. Submit a request of acceptance after a commissioning period per Section 01810 – Commissioning without any restarts to the ENGINEER for approval.
10. All parts and maintenance materials required to repair the system prior to completion of the OAD shall be supplied by CONTRACTOR, at no additional cost to OWNER. If parts are obtained from the contractual spare parts

inventory, they shall be replaced to provide a full complement of parts as specified.

11. A System Malfunction/Repair Reporting Form shall be completed by the OWNER and ENGINEER to document system failures, to record CONTRACTOR notification, arrival and repair times and CONTRACTOR repair actions. Format of the form shall be developed and agreed upon prior to the start of the OAD.

+ + END OF SECTION + +

SECTION 01781

OPERATIONS AND MAINTENANCE DATA

PART 1 - GENERAL

1.1 DESCRIPTION

A. Provide Operation and Maintenance Data in the form of instructional manuals for use by the OWNER'S personnel for:
   1. All equipment and systems.
   2. All valves, gates and related accessories.
   3. All instruments and control devices.
   4. All electrical gear.

B. Training or start-up on any system, process, or piece of equipment shall **not** be allowed until Operation and Maintenance Manuals are reviewed by the ENGINEER and the Operation and Maintenance Manuals have been turned over and approved by OWNER as per 1.1.D.3.

C. Definitions:
   1. Operation and Maintenance Data:
      a. The term "Operation and Maintenance Data" includes all product related information and documents which are required for preparation of the operation and maintenance manual. It also includes all data which shall accompany said manual as directed by current regulations of any participating government agency.
      b. Required Operation and Maintenance Data includes, but is not limited to, the following:
         1) A copy of the specification section in which the Operations and Maintenance Manual applies.
         2) Complete, detailed written operating instructions for each product or piece of equipment including equipment function; operating characteristics; limiting conditions; operating instructions for startup, normal and emergency conditions; regulation and control; and shutdown.
         3) Complete, detailed written preventive maintenance instructions as defined below.
         4) Recommended spare parts lists, by generic title and identification number, and local sources of supply for parts.
         5) Written explanations of all safety considerations relating to operation and maintenance procedures, including Material Safety Data Sheets (M.S.D.S.'s).
         6) Provide the completed Equipment Manufacturer/Vendor/Installer Form. Form to include: name, address, phone number, fax number,

e-mail address, and website of manufacturer, manufacturer's local service representative (at a minimum), and subcontractor or installer. Form is located in Section 01331 – Reference Forms, form number 01600-C. If multiple manufacturers of equipment are provided in a single manual, provide a separate form for each.

7) Copy of warranty bond and service contract, as applicable.
8) As-built circuit diagrams, wiring diagrams, schematics and functional drawings, as applicable, and either a nameplate drawing or a copy of nameplate.
9) Control Panel Drawings as required by Specification 17260 are to be provided in hard copy and electronically in AutoCAD version 2004 or newer.
10) Final test data, where applicable, shall be submitted as an appendix when completed.
11) Disassembly, reassembly, installation, alignment, adjustment, and checking instructions.
12) Provide installation data in accordance with Section 01731, Installation Data.
13) Written reference to CMMS Tag number, as specified under Section 01752, Equipment and System Startup and Performance Testing, paragraph 1.3.A.1.d., and as provided in Section 01630, Computerized Maintenance Management System Tags.
14) Provide the completed Equipment Information Forms, in accordance with the requirements of Section 01600, General Equipment Provisions. Form is located in Section 01331 – Reference Forms, form number 01600-A. If multiple manufacturers of equipment are provided in a single manual, provide a separate data sheet for each.
15) Provide a completed O&M Manual Review – Form is located in Section 01331 – Reference Forms, form number 01781-B – Operations & Maintenance Data Review Check List.
16) Material Safety Data Sheets (M.S.D.S.'s) for all fluids, oils, chemicals, and volume of each liquid used by each piece of equipment being supplied.

2. Preventive Maintenance Instructions:
   a. The term "preventive maintenance instructions" includes all information and instructions required to keep a product or piece of equipment properly maintained according to the manufacturer's recommendation to fulfill the equipment warranty condition and that the equipment or asset will reach its maximum potential life.
   b. The maintenance tasks frequency are driven by calendar, run-time, or meter reading.

D. Submittals:
   1. Operations and Maintenance Manual
      a. Submit operations and maintenance data to the ENGINEER within 30 calendar) days after approval of Shop Drawings, unless noted otherwise.
      b. Final approval of all O&M Manuals will only be provided after the OWNER and ENGINEER have reviewed and approved the individual final O&M Manuals. A copy of the signed Final Approval checklist shall be included in the O&M Manuals provided to the OWNER.
      c. Preliminary Copies:
         1) Number of preliminary copies: 5 hard copiess and 1 digital PDF copy of each O&M Manual shall be submitted to the ENGINEER for review. The O&M Manual shall conform to the requirements as specified herein.
         2) Each preliminary O&M Manual must be submitted to and reviewed by ENGINEER, and approved by the OWNER 30 calendar days prior to equipment start-up. ENGINEER shall determine the timeline for the submittal review process.
      d. Final Copies:
         1) Number of Final Copies: 5 hard copies and 1 digital PDF copy of each manual.
         2) Not less than 30 calendar days prior to placing the equipment into service submit all final hard copies and soft copies of the approved O&M Manual (except for field test data) to the ENGINEER.
         3) Soft copy shall be on a CD, "pdf" format – including "character recognition", and shall include all information provided in hard copy. The pdf file shall be a complete electronic copy of the hardcopy with bookmarks set for each tab in the hardcopy. The size of the pdf file shall be limited to 50 Mb and labeled with the title of the manual and volume number. Volumes shall be organized in a rational manner with the separation at a bookmark tab. CD's must be properly labeled with the following: Facility Name, Project Title, WS number, Specification Section # and Title of Manual. Labels must be computer generated. Hand written labels are not acceptable.
      e. Format Requirements:
         1) Use 8-1/2-inch by 11-inch quality paper of a minimum 20 pound. Larger drawings or illustrations are acceptable if neatly folded to the size of 8-1/2-inch by 11-inch and each drawing or illustration placed inside of an individual clear plastic or vinyl sheet protector.
         2) All text must be legible typewritten or machine printed originals or high quality copies of same. Manuals that contain copies that are not clear, not completely legible, off-center, skewed, or where text or drawings are cut by the binding holes shall be subject to disapproval. Pages that contain approval or date stamps, comments or other markings that cover any portion of text or drawing are unacceptable.

Electronically transmitted facsimile (fax) copies are also unacceptable.

3) Each page shall have a binding margin of approximately 1-1/2-inches and be punched for placement in a “D-ring” loose-leaf binder. Provide minimum 1-inch size or larger, white in color, D-ring binders. Binders shall not be filled to more than 3/4 maximum of their capacity. Non-uniform binders will not be acceptable. Identify each binder with the following:
   a) Title "OPERATING AND MAINTENANCE INSTRUCTIONS".
   b) Title of Project.
   c) Specification Section Number and Title.
   d) Name of the Provider of the Manual.
   e) WSD WS#
4) Coordinate with the ENGINEER and OWNER to develop a comprehensive, practical, and consistent indexing system for the Operations and Maintenance Manuals. The ENGINEER and the OWNER shall review the indexing system before any manuals are submitted in draft form.
5) Use dividers and indexed tabs between major categories of information such as operating instructions, preventive maintenance instructions, or other. When necessary, place each major category in a separate binder.
6) Provide a Table of Contents for each binder. The Table of Contents will have an appendix place holder for the final Test Data Forms. The soft copy content shall be identical to the hard copy’s Table of Contents.
7) Identify products by their functional names in the table of contents and at least once in each chapter or Section. Thereafter, abbreviations and acronyms may be used if their meaning is explained in a table in the back of each binder. Use of model or catalog numbers or letters for identification is not acceptable.
8) Indicate all components of the equipment on catalog pages by highlighting or some other clearly definable medium for ease of identification.

f. Changes after Installation:
   1) Final test data, changes and/or upgrades made to the systems after initial installation and during the start-up and commissioning phases, including equipment information and as-built wiring schematics, shall be submitted as an appendix to the Operations and Maintenance Manuals.
   2) Digital PDF copies of all revised Shop Drawings and Documentation that represent changes made during start-up and commissioning shall be submitted to the ENGINEER to replace initial drawings and

documentation contained in the Operations and Maintenance Manuals.

2. Preventive Maintenance Instruction Submittal
   a. All preventive maintenance instruction described above in paragraph 1.1.C.2 shall be provided to the ENGINEER separate from the Operations and Maintenance Manual submittal. The submittal timeline shall be determined by the ENGINEER; however, the City requires that all new assets and their preventive maintenance tasks are documented into the CMMS when the assets are ready for the commissioning process.
   b. Preventive maintenance information shall be reviewed and approved by the department's Asset Management Group. The information shall be per the asset's manufacturer's recommendation and includes, but is not limited to, the following:
      1) The manufacturer's written procedure on how to perform the preventive maintenance task with illustrations for each preventive maintenance task including list of required specialty tools.
      2) Recommended schedule/frequency for execution of each preventive maintenance task.
      3) List all assets that need the specific preventive maintenance task.
      4) Estimate of duration in hours to perform each preventive maintenance task. This value should only reflect just the time to perform the preventive maintenance task itself and not include any preparation/access time. It is also assumed that the staff has the necessary maintenance skill to perform the task.
      5) Number of staff needed perform the preventive maintenance task
   c. The manufacturer's preventive maintenance task procedure shall be provided in electronic format (MS WORD file format or PDF with optical character recognition (OCR) feature). The ENGINEER shall format the preventive maintenance information and instructions into the MS EXCEL file format and arrange as indicated in the example below.

Preventive Maintenance Description		**Est. Hrs**	**Est. Staff**	**Freq.**	**Unit**	**Procedure No.**
1	*Change oil*	*2*	*1*	*12*	*mos*	*"1234"*
2	*Change seals*	*5*	*2*	*200*	*hrs*	*"6789"*
3	----	---	---	---	---	---

Assets IDs	**Asset Decription**
12345678	*Raw Water Pumping, Pump No.2*
98765432	*Finished Water Pumping, Pump No. 4*
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1.2 OPERATION AND MAINTENANCE

A. Operation and Maintenance data shall be provided for the following equipment.

Equipment	*Specification Section*
Electric Motors larger than 250 Horsepower	11001
End Suction Submersible Pumps	11318
Packaged Biofilter Odor Control	13126
Stainless Steel Slide Gates	11287
Plug Valves	15112
Check Valves	15114
Specialty Valves	15119
Disconnect Switches	16143
Variable Frequency Drives	16425
Uninterruptible Power System	16443
Level Sensor	17051
Pressure Transmitter	17052
PLC	17262

1.3 OPERATIONS AND MAINTENANCE TRANSMITTAL FORM

A. Upon receipt of the Vendor Operations & Maintenance Manual from the Manufacturer /Supplier, complete the CONTRACTOR review and submit the Operations and Maintenance Transmittal Form as specified in Section 01331, Form 01781-A to the ENGINEER. ENGINEER to complete the form and attach to the Manual when delivered to the OWNER.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 01782

RECORD DOCUMENTS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Maintain and provide the ENGINEER with Record Documents as specified below, except where otherwise specified or modified in Division 2, Site Work, through Division 17, Instrumentation.

B. Definitions
   1. Contract Documents: The contract documents include the drawings, specifications, and addenda developed and furnished to the CONTRACTOR at the beginning of construction.
   2. As-Built Drawings: As-built drawings are an annotated set of drawings prepared by the CONTRACTOR. They show, in red, as-constructed changes to the original Contract Documents that have been made during the construction process. The As-Built Drawings may include supplemental drawings to provide the necessary detail, comply with project standards or where annotation would otherwise be impractical.
   3. Record Drawings: Record Drawings are prepared by the ENGINEER and reflect as-constructed changes that the CONTRACTOR annotated in the As-Built Drawings.
   4. Record Documents: The Record Documents include Record Drawings, specifications, addenda, approved shop drawings, samples, photographs, change orders, other modifications to the Contract Documents, test records, survey data, field orders, Request for Information, submittals and all other documents pertinent to the CONTRACTOR'S Work.

C. Maintenance of Documents:
   1. Three sets of black line sets of plans, including any Addenda, of the Drawings will be furnished to CONTRACTOR by the OWNER.
   2. Maintain in CONTRACTOR'S field office in clean, dry, legible condition complete sets of the following: Drawings, Specifications, Addenda, approved Shop Drawings, Samples, Photographs, Change Orders, other modifications of Contract Documents, test records, survey data, Field Orders, and all other documents pertinent to CONTRACTOR'S Work.
   3. Provide files and racks for proper storage and easy access. File in accordance with filing format of Construction Specification Institute (CSI), unless otherwise approved by ENGINEER.
   4. Make documents available at all times for inspection by ENGINEER and OWNER.
   5. Record Documents shall not be used for any other purpose and shall not be removed from CONTRACTOR'S office without ENGINEER'S approval.

6. Any contractually required testing provided by others shall be thoroughly documented by the CONTRACTOR and maintained with the project Record Documents. All testing results shall be maintained in their own separate log for the project; being kept current weekly and made readily available for viewing at any time.

D. Marking System: Changes, revisions, additions and deletions, to the record set of Drawings shall be marked in Red.

E. Recording:
1. Submit as-built drawings and make a record of the locations of all work completed as part of the project. The as-builts must indicate the locations of the beginning(s) and end(s) of the construction, and all valves, fire hydrants, pipe fittings, service connections and appurtenances. They must also show locations and elevations where significant elevation changes occur or changes in direction in all pipe alignments. Their locations must be shown by stationing and dimensioning from appropriate monument lines or in their absence appropriate lot lines, property lines or easement line references.
2. Label the Cover Sheet, Index and each supplemental sheets of each document "PROJECT RECORD" in 2-inch high printed letters.
3. Keep the As-Built Drawings current. CONTRACTOR'S refusal, failure or neglect to maintain current As-Built Drawings shall constitute sufficient basis for the ENGINEER to recommend the withholding of some or all of any payment due.
4. Do not permanently conceal any Work until required information has been recorded.
5. Drawings: Legibly mark to record actual construction including:
   a. Depths of various elements of foundation in relation to datum.
   b. Horizontal and vertical location of underground utilities and appurtenances referenced to permanent surface improvements.
   c. Location of internal utilities and appurtenances concealed in construction referenced to visible and accessible features of structure.
   d. Field changes of dimensions and details.
   e. Changes made by Change Order or Field Order.
   f. Details not on original Drawings.
6. Specifications and Addenda: Legibly mark up each Section to record:
   a. Manufacturer, trade name, catalog number, and supplier of each product and item of equipment actually installed.
   b. Changes made by Change Order or Field Order.
   c. Other matters not originally specified.

F. Record Drawings:
1. As-Build Drawings shall be prepared for all the Work included in the Contract. On a weekly basis, furnish to the ENGINEER a full size annotated copy of the As-Build Drawings that include changes from the previous week's As-Build Drawing submittal. Annotations shall include redlined "clouds" of only those

changes from the previous week's submittal. The redlined As-Build Drawings shall show the actual in-place installation of the items installed under this Contract. The redlined As-Build Drawings shall show the Work in plan and sections as required for clarity with reference dimensions and elevations that will be used to develop complete Record Drawings.

2. Develop and furnish to the ENGINEER, redlined Instrumentation and Control and Electrical Drawings showing one line diagrams with all conduit and wire sizes shown of the distribution systems and the actual in-place grounding system, lighting arrangement, motor control centers, corrected wiring diagrams, equipment and conduit and cable plans.
    a. The Contract Drawings may be used as a starting point in developing these Instrumentation and Control and Electrical As-Build Drawings. Subcontractor and manufacturer drawings may be included in this drawing package. The drawing package must be fully integrated and include the necessary cross references between drawings. The drawing package shall include interconnection and termination details to equipment furnished under this Contract.
    b. All As-Build Drawings must be submitted on a weekly basis for approval of the ENGINEER. This shall include the following composite drawings for the system being furnished:
        1) Schematic (Elementary) Diagrams: This shall include, but not be limited to, complete schematics including items furnished by others for the following:
            a) Motor Control Circuits for Starters furnished under this Contract.
            b) HVAC Control Panels furnished under this Contract.
        2) Wiring (Connection) Diagrams: These shall be included for all pre-wired equipment furnished under this Contract.
        3) Interconnection Diagrams: These shall include all interconnections to be furnished under this Contract.
        4) Conduit and Cable Schedules: These shall include all conduit and cable furnished under this Contract.
        5) Dimension of Outline Drawings: These shall include all equipment furnished under this Contract.
        6) Power and Lighting Layout Drawings: These shall include all conduits and wiring furnished under this Contract.
3. In addition to the redlined As-Build Drawings, prepare and submit CADD ".dwg" files, version 2004 or version approved by the OWNER, for all supplemental drawings used to complete the As-Build Drawings.
4. Survey results shall be posted to the as-builts on a weekly basis.

G. Submittals:
1. Acceptance of CONTRACTOR'S monthly application for payment shall be dependent on the ENGINEER'S acceptance and agreement that CONTRACTOR'S As-Build Drawings and weekly submittals are complete, thorough and acceptable in showing all Work up through and including such

work as CONTRACTOR is claiming for completion and payment on CONTRACTOR'S application for payment. Any items which do not appear on the As-Build Drawings in complete and acceptable form shall not be paid for in CONTRACTOR'S monthly payment.

2. Examination by the ENGINEER of CONTRACTOR'S As-Build Drawings will be made on a weekly basis to determine completion for consideration of monthly pay application. Also, make available all As-Build Drawings at all times to the ENGINEER for examination.
3. Prior to Completion of the Work, deliver final As-Build Drawings to ENGINEER. Substantial completion will not be made until satisfactory final As-Build Drawings are received by ENGINEER.
4. Accompany final and weekly submittals with transmittal letter containing:
   a. Date.
   b. Project title and number.
   c. CONTRACTOR'S name and address.
   d. Title and number of each As-Build Drawings.
   e. Certification that each document as submitted is complete and accurate.
   f. Signature of CONTRACTOR, or his authorized representative.

PART 2 - PRODUCTS (NOT USED)

PART 3 -EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 01783

SPARE PARTS AND MAINTENANCE MATERIALS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Submit a complete list of all spare parts required for the project for review and comments to the ENGINEER and OWNER by no later than 50 percent of the project construction completion. The list shall include details such as equipment identification, part description, manufacture, and manufacturer part number, location in system, local vendor, storage requirements, storage location, and approximate cost. This completed list will be used to inventory all parts at time of turn over to the OWNER.

B. Spare parts and materials required to be supplied in the Contract Documents shall be furnished in manufacturer's unopened cartons, boxes, crates or other protective covering suitable for preventing corrosion or deterioration for the maximum length of storage which may be normally anticipated. They shall be clearly marked and identified as to the name of manufacturer or supplier, applicable equipment, part number, description and location in the equipment. All parts shall be protected and packaged for a shelf life of at least ten years.

C. During construction, store parts in buildings or trailers with floor, roof and closed sides and in accordance with manufacturers' recommendations. Protect from weather, condensation and humidity.

D. Parts and materials shall be delivered to the OWNER upon Substantial Completion of the Work or during the commissioning period of the system. Until that occurs, place spare parts in permanent storage rooms or areas approved by the OWNER. The turnover procedures shall be developed by the ENGINEER.

E. Provide a letter of transmittal along with the Spare Parts Receiver Form 01783-A in Specification 01331 – Reference Forms.

F. Full responsibility for loss or damage to parts and materials until they are transmitted to the OWNER, belongs to CONTRACTOR.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 01784

POST FINAL INSPECTION

PART 1 - GENERAL

1.1 DESCRIPTION

A. Approximately four to six months after the date of substantial completion, ENGINEER will make arrangements with OWNER and CONTRACTOR for a Post-Final Inspection and will send a written notice to OWNER and CONTRACTOR advising of the date and time of the inspection.

B. After the inspection, ENGINEER will inform CONTRACTOR of any corrections required.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 01810

COMMISSIONING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section Includes: Responsibility of the OWNER, ENGINEER and CONTRACTOR during the Commissioning Phase(s) of the Project.

B. Start-up and Commissioning of the Work, or a specified part of the Work, under this Project shall be as described in Section 01111, Schedule of Completion and Section 01143, Coordination with OWNER'S Operations. Work under this Section shall not start until the Work under Section 01111, Schedule of Completion, Section 01143, Coordination with OWNER'S Operation, Section 01751, Starting and Placing Equipment in Operation, Section 01752, Equipment and System Start-Up and Performance Testing; Section 01781, Operation and Maintenance Data, Section 01782, Record Documents and Section 01821, Instruction of Operations and Maintenance Personnel. Also, Special Tests as defined under the individual technical specifications, Divisions 0 to 18 has been completed; and Notice of Substantial Completion for the Work as defined in the Supplementary Conditions has been completed and issued by the ENGINEER. Spare parts shall also be on-site and accepted prior to Commissioning.

1.2 DEFINITIONS

A. Commissioning: The sequential process in which a newly constructed facility is put into successful operation.

B. Successful Operation: The resultant operation of all the processes and related controls in a manner that is consistent with the Contract Documents.

C. Manual Operational Mode: This operational mode represents the lowest level of control philosophy utilized in the plant instrumentation and control system. For all practical purposes, it means that an operational control decision requiring equipment or process monitoring or control will require an individual to physically go to the local control for the associated task in order to operate the facility. In the manual operational mode, the focus will be on verifying that the equipment and processes function correctly, independent of the instrumentation system and control system. The estimated duration of the manual commissioning period is 25 percent of the total Work/Work area commissioning duration.

D. Semi-Automatic Operational Mode: The highest level of control philosophy utilized in the plant instrumentation and control system.

1.3 SUBMITTALS

A. Preventive and Unscheduled Maintenance Plan: Submit detailed plan prior to start of Commissioning for providing all preventive and unscheduled maintenance of all equipment and facilities in the plant throughout the entire commissioning phase of the project.

B. OWNER'S Personnel Training Schedule and Plan: Submit detailed plan and schedule for training OWNER'S personnel in accordance with Section 01821, Instruction of Operations and Maintenance Personnel.

1.4 REQUIREMENTS

A. Commissioning process will commence after issuance of the Work/Work area Notice of Substantial Completion to CONTRACTOR.

The commissioning process for the Project will consist of the following:

Commissioning Phases			
Phase	**Work/Work Area**	**Commissioning Requirements**	**Commissioning Duration (Calendar Days)**
Phase 1 – Manual/Semi-Auto Performance Test	Submersible Pumps and Biofilter	All equipment and instruments in manual (local) and semi automatic modes of operation	14 consecutive uninterrupted days
Phase 2 – Automatic Performance Test	Submersible Pumps and Biofilter	All equipment and instruments in automatic modes of operation	14 consecutive uninterrupted days
Phase 3 – OWNER Automatic Demonstration Test	Submersible Pumps and Biofilter	All equipment and instruments in automatic modes of operation	30 consecutive uninterrupted days

Items required to be completed prior to the start of Commissioning include:

1. All Vendor Operations & Maintenance Manuals.
2. All required Training.
3. All required spare parts.
4. After approval of the Specification 01630 - Computerized Maintenance Management System Tags, CONTRACTOR shall provide and install all tags.
5. Any other items required under the contract.

D. During the course of the Commissioning Process and Phases, the ENGINEER and OWNER will evaluate design related issues and recommend design modifications which shall be implemented by CONTRACTOR through the Change Order process.

E. No system or subsystem shall be started up for continuous operation unless all components of that system or subsystem, including instrumentation, have been tested and proven to be operable as intended by the Contract Documents.

1.5 RESPONSIBILITIES

A. Responsibilities listed do not relieve CONTRACTOR from all other responsibilities and duties associated with project closeout as defined in Division 0 and Division 1, General Requirements of the Specifications.

B. CONTRACTOR'S Responsibilities during the Commission Process:
   1. Provide on call service (24 hours per day and seven days per week), which includes all staff, labor, materials, equipment and appurtenances required for carrying out CONTRACTOR'S commissioning duties described below.
   2. All Change Order work resulting from the evaluation of design-related issues by the ENGINEER and OWNER.
   3. All preventive and unscheduled maintenance of all equipment and facilities. This shall include, but not be limited to the following:
      a. Providing all lubricants.
      b. Lubrication of all equipment in accordance with Manufacturer's recommendations.
      c. Perform all Manufacturer recommended preventive maintenance, including instrument calibrations.
      d. Exercise all equipment not in use during Commissioning phase.
      e. Repair all failed equipment.
      f. Periodic check of all equipment alignment, vibration, and noise levels to ascertain conformance with Specifications.
      g. Provide all parts required for equipment repair.
      h. Provide all tools and miscellaneous equipment required for equipment repair.
      i. Administration/logging/documentation of all preventive maintenance and repair work.
      j. Cleanup associated with equipment failure and repair.
      k. Daily cleanup of buildings and site.
      l. Landscaping maintenance.
      m. Roadway cleanup and maintenance.
      n. Replacement of all HVAC filters.
   4. Warranty related issues/items.
   5. Other contractual requirements including, but not limited to, incomplete Work list.

C. OWNER'S Responsibilities during the Commissioning Process:
   1. Perform all laboratory analysis required for plant operations.
   2. Assisting ENGINEER in the evaluation of design related issues and recommendations of modifications to be implemented by CONTRACTOR through the change order process.

D. ENGINEER'S Responsibilities during Commissioning Process:
   1. Answer technical questions from the CONTRACTOR and OWNER with Operation of facilities.
   2. Provide liaison and coordination between CONTRACTOR and OWNER'S activities.
   3. Administer any Change Order work performed by CONTRACTOR.

E. Based upon the data compiled during the commissioning period modifications may be required. The ENGINEER and OWNER may issue a request for proposal to modify the Work, to change design or process related issues. A respond to these requests is expected.. Appropriate cost and time adjustment will be made to address the proposed change.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 01821

INSTRUCTION OF OPERATIONS AND MAINTENANCE PERSONNEL

PART 1 - GENERAL

1.1 DESCRIPTION

A. Provide the services of factory-trained maintenance specialists to instruct OWNER'S operations and maintenance personnel in the recommended operation and the preventive maintenance procedures for equipment specified in the equipment Sections.

B. The qualifications of specialists shall be subject to approval by ENGINEER.

C. Coordinate these services at times acceptable to OWNER and ENGINEER, with a minimum of 14 days prior notice.

D. Manufacturer shall provide a combination of classroom and field training. All training shall be conducted at the Facility, unless otherwise stated in the equipment Sections. Class size shall be limited to no more than 15 trainees. Manufacturer shall provide training for all plant shifts, or as approved by OWNER.

E. Manufacturer shall allow any and all training sessions to be videotaped by OWNER.

F. Section 01600, General Equipment Provisions, Section 01620, Installation of Equipment, Section 01751, Starting and Placing Equipment in Operation, and Section 01752, Equipment and System Startup and Performance Testing, includes, additional requirements for manufacturer's and supplier's field and test data.

G. Instruction of OWNER'S personnel shall commence only after the equipment has been started, approved Operation and Maintenance Manuals have been turned over to the OWNER, and acceptance tests have been completed according to the provisions in Section 01751, Starting and Placing Equipment in Operation, and Section 01752, Equipment and System Startup and Performance Testing.

H. Submit a copy of this Section 01821, Instruction of Operations and Maintenance Personnel, to all manufacturers of equipment for this contract.

1.2 SUBMITTALS

A. The CONTRACTOR shall submit to the ENGINEER for review and comment, by no later than 60 percent of project construction, a complete list of all training

courses and duration of each training course required in the specifications and contract documents.

B. No later than 75 percent project construction completion the Manufacturer or Manufacture Representative shall develop and submit for approval the following:
   1. Proposed Lesson Plan for each scheduled instruction 14 calendar days prior to commencement of training. Lesson plans shall be approved minimum of 7 calendar days prior to scheduled instruction.
   2. Credentials of their designated operations and maintenance instructor shall include a brief resume and specific details of the instructor's experience pertaining to; operation of, maintenance of, and training for the equipment specified.
   3. Training Request Form: Submit the Training Request Form to the ENGINEER 14 calendar days prior to the requested training date. Form is located in Section 01331 – Reference Forms, form number 01821-B.
   4. There shall be separate "Operations" and "Maintenance" staff training.

1.3 INSTRUCTION LESSON PLAN

A. Manufacturer's proposed Lesson Plan shall include the elements presented in the outline of Instruction Lesson Plan in Paragraph 1.3.D., below, of this Section. Specific components and procedures shall be identified in the proposed Lesson Plan.

B. Manufacturer's proposed Lesson Plan shall detail specific instruction topics. Training aids to be utilized in the instruction shall be referenced and attached where applicable to the proposed Lesson Plan. "Hands-On" demonstrations planned for the instruction shall be described in the Lesson Plan.

C. The manufacturer shall indicate the estimated duration of each segment of the training Lesson Plan.

D. Instruction Lesson Plan shall include the following as a minimum:
   1. Equipment Operation:
      a. Describe equipment's operating (process) function.
      b. Describe equipment's fundamental operating principals and dynamics.
      c. Identify equipment's mechanical, electrical and electronic components and features.
      d. Identify all support equipment associated with the operation of subject equipment (e.g., air intake filters, valve actuators, motors).
      e. Recommend standard operating procedures to cover start-up, routine monitoring and shutdown of the equipment.
   2. Detailed Component Description:
      a. Identify and describe in detail each component's function.

b. Where applicable, group related components into subsystems. Describe subsystem functions and their interaction with other subsystems.
c. Identify and describe in detail equipment safeties and control interlocks.

3. Equipment Preventive Maintenance (PM):
   a. Describe PM inspection procedures required to:
      1) Perform an inspection of the equipment in operation.
      2) Spot potential trouble symptoms and anticipate breakdowns.
      3) Forecast maintenance requirements (predictive maintenance).
   b. Define the recommended PM intervals for each component.
   c. Provide lubricant and replacement part recommendations and limitations.
   d. Describe appropriate cleaning practices and recommend intervals.
   e. Identify and describe the use of special tools required for maintenance of the equipment.
   f. Describe component removal/installation and disassembly/assembly procedures.
   g. Perform at least two "hands-on" demonstrations of preventive maintenance procedures.
   h. Describe recommended measuring instruments and procedures, and provide instruction on interpreting alignment measurements, as appropriate.
   i. Define recommended torquing, mounting, calibration and/or alignment procedures and settings, as appropriate.
   j. Describe recommended procedures to check/test equipment following a corrective repair.
4. Equipment Troubleshooting:
   a. Define recommended systematic troubleshooting procedures.
   b. Provide component specific troubleshooting checklists.
   c. Describe applicable equipment testing and diagnostic procedures to facilitate troubleshooting.

1.4 TRAINING AIDS

A. The manufacturer's instructor shall incorporate training aids as appropriate to assist in the instruction. As a minimum, the training aids shall include text and figure handouts. Other appropriate training aids are:
   1. Audio-Visual Aids (e.g., films, slides, videotapes, overhead transparencies, posters, blueprints, diagrams, catalogue sheets).
   2. Equipment cutaways and samples (e.g., spare parts and damaged equipment).
   3. Tools (e.g., repair tools, customized tools, measuring and calibrating instruments).

B. The manufacturer's instructor shall utilize descriptive class handouts during the instruction. Photocopied class handouts shall be good quality reproductions. Class handouts should accompany the instruction with frequent reference made to them.

Customized handouts developed especially for the instruction are encouraged. Handouts planned for the instruction shall be attached with the manufacturer's proposed Lesson Plan.

1.5 "HANDS-ON" DEMONSTRATIONS

A. The manufacturer's instructor shall present "hands-on" demonstrations of operations and maintenance of the equipment for each scheduled group. The proposed "hands-on" demonstrations should be described in the manufacturer's proposed Lesson Plan.

1.6 TRAINING SCHEDULE

A. Each manufacturer shall provide as a minimum the following minimum hours of onsite training. Travel time and expenses are responsibility of manufacturer and are not included in training schedule time.

Equipment	*Section*	*Training Hours*
End Suction Submersible Pumps	11318	8
Packaged Biofilter Odor Control System	13126	8

B. The plant operators work on a shift schedule. Develop the training schedule to account for training classes for each shift.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 02145

DIVERSION OF WATER OR SEWAGE FLOW AND DEWATERING

PART 1 – GENERAL

1.1 DESCRIPTION

A. Scope:
   1. This section describes the existing conditions for temporary bypassing and dewatering of water systems or sewers for internal television inspection (CCTV), cleaning operations and/or rehabilitation of project pipelines. Temporary bypass pumping is very important for the project, including the maintenance of service to customer connections or making alternative arrangements acceptable to customers.

B. Requirements:
   1. Proved all labor, materials and supervision to temporary bypass flow around the work in accordance with the specified needs of the rehabilitation method being utilized and dewater the pipelines in preparation for cleaning and rehabilitation.
   2. Provide the design of the bypass arrangement and describe the means and methods of accomplishing the bypassing and submitted to the ENGINEER to determine conformance to project objectives.
   3. Prior to placing the bypass system into operation, successfully test the system to 1.5 times the maximum operating pressure of the system.
   4. Notify the ENGINEER 48 hours prior to shutting down or operating the bypass. Provide continuous manned monitoring of the bypass flow.
   5. Should a spill occur, immediately contact the ENGINEER and provide immediate and proper cleanup.

C. Experience:
   1. Utilize staff and/or a subcontractor that has been directly responsible for the completion of a project that required the bypass pumping of water or sewage flows in excess of 16 mgd.

1.2 SUBMITTALS

A. At the Preconstruction Conference, submit drawings and complete design data showing methods and equipment proposed to be utilized in the water piping or sewer bypassing for review by the ENGINEER. Include the following information in the submittal.

1. Drawings indicating the scheme and location of temporary water or sewer line plugs, bypass discharge lines and the method and location for discharging the bypass lines.
2. Capacities of pumps, prime movers and standby equipment.
3. Design calculations proving adequacy of the system and selected equipment sealed by a Professional Civil Engineer, registered in the State of Arizona.
4. Standby Power Source
5. Staffing Plan
6. Secondary Containment Provisions
7. Spill Response Plan
8. Odor Control Plan

1.3 JOB CONDITIONS

A. Available Flow Data:
   1. Available flow data for the water systems or sewers to be rehabilitated at the projects is located in Part 3, Section 3.1 of this specification. Flow data for the service laterals is not available. Determine the flow in service laterals and submit the data to the ENGINEER.

B. Protection:
   1. Bypassing to the ground surface, receiving waters, storm drains or bypassing which results in soil or groundwater contamination or any potential health hazards is not permitted.

C. Scheduling:
   1. The bypassing system is not allowed to be shut down between shifts, on holidays, weekends or during work stoppage without written permission from the ENGINEER. Provide an attendant, around the clock, whose only duty is to maintain the bypass pumping system until the bypassing of that specific pipeline is no longer required.

D. Service Lines:
   1. Water or sanitary sewers to be bypassed may have service lines connected to adjacent users. The known service lines have been shown on the construction drawings. Verify the locations of these lines and any other service lines not shown on the drawings.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Provide temporary pumps, conduits and other equipment to bypass flow around the work area. Furnish all necessary labor and supervision to set up and operate the pumping and bypass system.
   1. Provide critical grade sound attenuated pumps capable of achieving an operating noise level of 70 decibels or less measured at a distance of 50 feet from the operating pump for the bypass pumping. Conduct sound measurement tests in accordance with the American National Standards S. 13-1971.
   2. Provide pumps and bypass lines of adequate capacity and size to handle the required capacity.
   3. Each internal combustion engine, used for any purpose on the job or related to the job, shall be equipped with a muffler of a type recommended by the manufacturer. No internal combustion engine shall be operated on the project without said muffler.

B. Maintain on site, sufficient equipment and materials to ensure continuous and successful operation of the bypass system. Unless otherwise approved by ENGINEER, provide standby pumps on site for a minimum 50% redundancy of the bypass system flow except at least 100% redundant capacity must be provided if only one pump is being used to bypass flows. Provide, install in-place, make fully operational and be fueled at all times the standby pumps, equipment and piping. Maintain on site a sufficient number of valves, tees, elbows, connections, tools, water line or sewer plugs, piping and other parts or system hardware to ensure immediate repair or modifications of any part of the system as necessary.

C. Unless otherwise approved by ENGINEER, provide and install fully operational redundant bypass line(s) so they can be placed in service in the event one of the bypass lines develops a leak. Provide 33% redundancy in the bypass piping for design flows, except at least one redundant bypass line must be provided when less that three bypass lines are provided by design. Provide and install independent valves on all lines for the bypass pump system so they can be quickly activated or removed form service if necessary.

D. Install all pumps, generators and other equipment with sufficient secondary containment to protect against gasoline, oil and hydraulic fluid spills. Provide a berm at the edge of the containment to prevent direct runoff of spills.

PART 3 – EXECUTION

3.1 ESTIMATED FLOWS IN THE PROJECT PIPELINE

A. The following paragraph provides estimated peak daily dry weather flow information for the project pipeline. The information was obtained from the City of Phoenix. For questions pertaining to this information contact the City of Phoenix, Water Services Department, 200 West Washington Street, Phoenix, Arizona, during normal business hours.

B. The approximate estimated dry weather low flow, average daily dry weather flow and peak dry weather flow for Lift Station 66 are listed below in Table 1. Use of this flow data in no way relieves responsibilities for design, construction and operation of an adequate and properly functioning bypass system. Rain events may result in significantly larger flow rates. Make own determination of bypass capacity needs. The bypass design must provide sufficient capacity to handle this increase.

TABLE 1

Dry Weather Flow Estimates

Location:	Low Flow:	Average Flow:	Peak Flow:
Lift Station 66	4	10	16

C. Monitoring Flows:
   1. Monitor flows and bypass operations during the course of the project to ensure proper operation and ensure against upstream surcharges and/or spills.

D. Service Lines:
   1. Water or sewer service to customers must be maintained during the course of the work, unless other acceptable arrangements are made with the customer.
   2. The ENGINEER shall provide a public information representative to accompany the CONTRACTOR when visiting customers to discuss bypass pumping of services or making alternate arrangements with the customer to discuss bypass pumping of services or making alternate arrangements with the customer for service outages.
      a. No matter what arrangement is made, cooperate with the ENGINEER to provide the City of Phoenix documentation that all affected customers have been contacted and arrangements made for continuous service or alternate accommodations. This document must be submitted prior to start of work on the section of line affected.

E. Notifications;
   1. Cooperate fully in providing the ENGINEER with advance notice and details pertaining to work schedule and individual service arrangements.

   2. Notify the ENGINEER and City of Phoenix of any planned service interruptions at least two weeks prior to the event.

   3. The ENGINEER or local public involvement firm retained by the ENGINEER shall perform notification of the work to the public. Notification shall be made door to door with printed handouts or door hangers. The information provided includes, at a minimum, the reason for the interruption, the time period of the interruption and a local 24 hour telephone hotline number for project information.
      a. The first notification is to be five days before interruption of service. Much grater advance notice may be required if an alternate to pumping the customer's service is proposed.
      b. The second notification is to be 24 hours prior to interruption of service.

3.2 PROTECTION

A. Water or wastewater spills, overflows and backups into customer's properties are not allowed. Bypassing to the ground surface, receiving waters, storm drains or bypassing which results in groundwater contamination or potential health hazards are not allowed.

B. Inspect the entire bypass pumping and piping system for leaks or spills on an hourly basis. Create an inspection log and enter the time of the inspections and the conditions of the piping and the name of the inspector into the log for review by the ENGINEER.

C. Provide ENGINEER a copy of an emergency spill response plan. Plan shall address notification and clean up procedures. Immediately take action to halt and clean up all spills and immediately notify ENGINEER of any/all spills.

D. Perform all work in compliance with OSHA standards and in no case will noise levels be permitted which would interfere with the work of the City or others. Noise levels shall be in accordance with City of Phoenix noise ordinance. Utilize sound attenuated bypass pumps with a maximum decibel rating of 70 db @ 50 feet.

E. Odor Control:
   1. Employ methods and procedures that mitigate the generation and discharge of objectionable odors to the surface environment at all times.

2. Add ferric chloride to the wastewater flow upstream of bypass pumping operations to reduce odor. Make determination of flow characteristic for required dosing.
    a. Add the ferric chloride from a location upstream that will allow 10 to 15 minutes reaction time before the flow enters the work area. The chemical dosing shall reduce odors generated from the wastewater stream to a level acceptable to the City. If this is not accomplished by adding the ferric chloride only, an additional control may be required. Add hydrogen peroxide downstream to the flow that has been dosed with ferric chloride. The Hydrogen peroxide shall be added to allow a 5 – minute reaction time before the flow enters the work area. Any dosage combination of the two chemicals may be used to ensure continuous control of odors acceptable to the City.

3.3 DAMAGES

A. Repairs for any damage that may result from negligence, inadequate or improper installation, maintenance, insufficient and operation of bypass system, including mechanical or electrical failures are the responsibility of the CONTRACTOR.

+ + END OF SECTION + +

SECTION 02220

DEMOLITIONS

PART 1 – GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required for demolitions, removal and disposal Work.
   2. Included, but not limited to, are demolition and removals of existing materials, equipment, or work necessary to install the Work as shown on the Drawings, specified and required to connect same with existing work in an approved manner. Demolition includes structural concrete, foundations, walls, doors, windows, structural steel, metals, roofs, masonry, attachments, appurtenances, piping, electrical and mechanical equipment, paving, curbs, walks, fencing, and similar existing facilities.
   3. Demolitions and removals which may be specified under other Sections shall conform to requirements of this Section.
   4. Pay for all landfill disposal fees.

1.2 SUBMITTALS

A. Schedule: Submit for approval proposed methods, equipment, and operating sequences. Include coordination for shut-off, capping, temporary services, continuation of utility services, and other applicable items to ensure no interruption of OWNER'S operations.

1.3 JOB CONDITIONS

A. Protection:
   1. Perform all demolition and removal Work to prevent damage or injury to structures, occupants thereof and adjacent features which might result from falling debris or other causes, and so as not to interfere with the use, and free and safe passage to and from adjacent structures.
   2. Closing or obstructing of roadways, sidewalks, and passageways adjacent to the Work by the placement or storage of materials will not be permitted, and all operations shall be conducted with a minimum interference to traffic on these ways.
   3. Erect and maintain barriers, lights, sidewalk sheds, and other necessary protective devices.
   4. Repair damage to facilities to remain, or to any property belonging to the OWNER or occupants of the facilities. Comply with requirements of Section 02230, Clearing.

B. Scheduling:
   1. Carry out operations so as to avoid interference with OWNER'S operations and work in the existing facilities. Comply with requirements of Section 01143, Coordination with OWNERS Operations.

C. Notification:
   1. At least 48 hours prior to commencement of a demolition or removal, notify ENGINEER, in writing, of proposed schedule therefore. OWNER will inspect the existing equipment and mark for identification those items which are to remain the property of the OWNER. Do not start removals without the permission of the ENGINEER.

D. Explosives:
   1. Do not bring explosives on site nor use explosives without written consent of authorities having jurisdiction. Such written consent will not relieve CONTRACTOR of total responsibility for injury or damage caused by CONTRACTOR'S blasting operations.
   2. Perform all blasting, if permitted, in compliance with applicable governing regulations.

PART 2 – PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 GENERAL

A. All materials and equipment removed from existing work, shall become the property of CONTRACTOR, except for those which OWNER has identified and marked for their use. All materials and equipment marked by the OWNER to remain the property of the OWNER shall be carefully removed by CONTRACTOR, so as not to be damaged, and shall be cleaned and stored on or adjacent to the site in a protected place specified by the ENGINEER or loaded onto trucks provided by the OWNER.

B. Dispose of all demolition materials, equipment, debris, and all other items not marked by the OWNER to remain off the site and in conformance with all existing applicable laws and regulations.

C. Surfaces of walls, floors, ceilings, or other areas which are exposed by any of the removals specified herein, and which will remain as architecturally finished surfaces shall be repaired and re-finished by CONTRACTOR with the same or matching materials as the existing adjacent surface or as may be otherwise approved by the ENGINEER.

D. Pollution Controls: Use water sprinkling, temporary enclosures, and other suitable methods to limit the amount of dust and dirt rising and scattering in the air to the

lowest practical level. Comply with governing regulations pertaining to environmental protection.

1. Do not use water when it may create hazardous or objectionable conditions such as ice, flooding, and pollution.
2. Clean adjacent structures, facilities, and improvements of dust, dirt, and debris caused by demolition operations. Return adjacent areas to conditions existing prior to the start of the Work.

E. Building Demolition:
   1. Unless otherwise approved by ENGINEER, proceed with demolition from the top of the structure to the ground. Complete demolition Work above each floor or tier before disturbing supporting members of lower levels.
   2. Demolish concrete and masonry in small sections.
   3. Remove structural framing members and lower to ground by means of hoists, derricks, or other suitable methods.
   4. Break up and remove foundations and slabs-on-grade, unless otherwise shown on the Drawings to remain.
   5. Locate equipment used for demolition Work, and remove demolished materials, so as to not impose excessive loads on supporting walls, floors or framing.

F. Pavement Demolition:
   1. All asphalt and concrete pavement demolition shall terminate at cut edges. All edges shall be linear and have a vertical cut face.

3.2 STRUCTURAL REMOVALS

A. Remove structures to the lines and grades shown on the Drawings, unless otherwise directed by the ENGINEER. Where no limits are shown on the Drawings, the limits shall be 4-inches outside the item to be installed. The removal of masonry beyond these limits shall be at CONTRACTOR'S expense and these excess removals shall be reconstructed to the satisfaction of the ENGINEER, with no additional compensation to CONTRACTOR.

B. All concrete, brick, tile, concrete block, roofing materials, reinforcement, structural or miscellaneous metals, plaster, wire mesh and other items contained in or upon the structure shall be removed and taken from the site, unless otherwise approved by the ENGINEER. Demolished items shall not be used in backfill.

C. After removal of parts or all of masonry walls, slabs and like work which tie into the Work or existing work, the point of junction shall be neatly repaired so as to leave only finished edges and surface exposed.

D. The jambs, sills and heads of any windows, passageways, doors, or other openings cut into the Work or existing work, shall be dressed with new masonry, concrete or metal to provide a smooth, finished appearance.

E. Where new anchoring materials, including bolts, nuts, hangers, welds and reinforcing steel, are required to attach the Work to the existing work they shall be included under this Section, except where specified elsewhere.

3.3 MECHANICAL REMOVALS

A. Mechanical removals shall consist of dismantling and removing of existing piping, pumps, motors, equipment and other appurtenances as specified, shown, or required for the completion of the Work. Mechanical removals shall include cutting, capping, and plugging as required, except that the cutting of existing piping for the purpose of making connections thereto will be included under Division 15, Mechanical.

B. Existing process, water, chemical, gas, fuel oil and other piping not required for the Work shall be removed where shown on the Drawings or where it will interfere with the Work. Piping not indicated to be removed or which does not interfere with the Work shall be removed to the nearest solid support, capped and left in place. Chemical and fuel lines and tanks shall be purged and made safe prior to removal or capping. Where piping that is to be removed passes through existing walls, it shall be cut off and properly capped on each side of the wall.

C. When underground piping is to be altered or removed, the remaining piping shall be properly capped. Abandoned underground piping shall be removed.

D. Waste and vent piping shall be removed to points shown. Pipe shall be plugged with cleanouts and plugs. Where vent stacks pass through an existing roof that is to remain, they shall be removed and the hole in the roof properly patched and made watertight.

E. Any changes to potable water piping and other plumbing and heating system work shall be made in conformance with all applicable codes and under the same requirements as other underground piping. All portions of the potable water system that have been altered or opened shall be pressure tested and disinfected in accordance with Section 15050, Piping Systems, and Section 15051, Buried Piping Installation, and local codes. Other plumbing piping and heating piping shall be pressure tested only.

3.4 ELECTRICAL REMOVALS AND DEMOLITION

A. Electrical removals shall consist of the removal of existing transformers, distribution switchboards, control panels, motors, conduits and wires, poles and overhead wiring, panelboards, lighting fixtures, and miscellaneous electrical equipment all as shown on the Drawings, specified, or required to perform the Work.

B. All existing electrical equipment and fixtures to be removed shall be removed with such care as may be required to prevent unnecessary damage, to keep existing systems in operation and to keep the integrity of the grounding systems.

C. Motor Control Centers and Switchgear shall be removed or modified as shown on the Drawings. Motor Control Centers and Switchgear to be removed shall be disconnected and dismantled, and all components shall be disposed of off the site. Circuit breakers and other control equipment on modified Motor Control Centers and Switchgear that will no longer be used shall be removed, unless otherwise shown on the Drawings or specified. All new openings cut into the modified Motor Control Centers and Switchgear shall be cut square and dressed smooth to the dimensions required for the installation of the new equipment.

D. Motors shall be disconnected and removed where shown on the Drawings or specified. Motors not designated by the OWNER to be salvaged shall be removed from the site. Motors or other electrical gear designated for reuse shall be stored in enclosed, heated storage.

E. Abandoned Exposed Conduit and Wire: Generally, whenever a piece or groups of equipment are removed, all associated electrical power or control wiring which are no longer required shall be removed. The wire shall be removed back to the power source or control panel. The conduit, unless otherwise indicated, shall be removed back to the nearest junction box or point of conduit embedment. Abandoned conduits or direct-burial cable concealed in floor or ceiling slabs, or in walls, shall be cut flush with the slab or wall at the point of entrance. The conduits shall be suitably plugged and the area repaired in a flush, smooth, approved manner. Exposed conduits and their supports shall be disassembled and removed from the site. Repair all areas of work to prevent rust spots on exposed surfaces.

F. Where shown on the Drawings or otherwise required, wiring in the underground duct or direct-burial cable system shall be removed. All such wiring shall be salvaged and stored as specified. Verify the function of all wiring before disconnecting and removing it. Ducts which are not to be reused shall be plugged where they enter buildings and made watertight.

G. Existing panelboards where shown on the Drawings shall be removed and disposed of off the site. Where shown on the Drawings or specified, they shall be replaced with new panelboards at the same or adjacent locations. All cutting and patching necessary for the removal and replacement of panelboards shall be performed.

H. Existing lighting fixtures shall be removed or relocated as shown on the Drawings. Fixtures not relocated shall be removed from the site. Relocated fixtures shall be carefully removed from their present location and reinstalled where shown on the Drawings.

I. Existing wall switches, receptacles, starters and other miscellaneous electrical equipment, shall be removed and disposed of off the site, as required. Care shall be taken in removing all equipment so as to minimize damage to architectural and

structural members. Any damage incurred shall be repaired by CONTRACTOR to the satisfaction of the ENGINEER, at no additional cost to the OWNER.

3.5 ALTERATIONS AND CLOSURES

A. Alterations shall conform with the Contract Documents, and the directions and approvals of the ENGINEER.

B. Where alterations require cutting or drilling into existing floors, walls, and roofs, the holes shall be repaired in a manner approved by the ENGINEER. Repair such openings with the same or matching materials as the existing floor, wall, or roof or as otherwise approved by the ENGINEER. All repairs shall be smoothly finished, unless otherwise approved by the ENGINEER.

C. Openings in existing concrete slabs, ceilings, masonry walls, floors and partitions shall be closed and sealed as shown on the Drawings or otherwise directed by the ENGINEER. The Work shall be keyed into the existing work in a manner approved by the ENGINEER. Reinforcing steel shall be welded to the existing reinforcing. Welding shall conform to AWS D12.1, Reinforcing Steel Welding Code. In general, use the same or matching materials as the existing adjacent surface. The finished closure shall be a smooth, tight, sealed, permanent closure acceptable to the ENGINEER.

3.6 CLEAN-UP

A. Remove from the site all debris resulting from the demolition operations as it accumulates. Upon completion of the Work, all materials, equipment, waste, and debris of every sort shall be removed and premises shall be left, clean, neat and orderly. Comply with requirements of Section 02315, Structural Excavation and Backfill, and Section 02230, Clearing.

+ + END OF SECTION + +

SECTION 02315

STRUCTURAL EXCAVATION AND BACKFILL

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals required to perform all excavating, backfilling, filling and grading, and disposing of earth materials as shown on the Drawings, specified, and required for construction of retaining walls, manholes, vaults, structure foundations, underground ductbanks, electrical manholes and handholes, and other structures and facilities required to complete the Work in every respect.
   2. All necessary preparation of subgrade for slabs, foundations and pavements is included.
   3. All temporary means required to prevent discharge of sediment to water courses from dewatering systems or erosion are included.
   4. No classification of excavated materials will be made. Excavation includes all materials regardless of type, character, composition, moisture, or condition thereof, except rock.
   4. On-site excavated material will be classified for use as backfill material. Excavation materials include all materials regardless of type, character, composition, moisture, or condition thereof.
   5. Perform all earthwork as specified in this Section.

1.2 QUALITY ASSURANCE

A. Testing Services:
   1. General: Testing of materials, testing for moisture content during placement and compaction of fill materials, and of compaction requirements for compliance with technical requirements of the Specifications shall be performed by a testing laboratory as designated in Section 01451, Testing Laboratory Services Furnished by OWNER, and Section 01452, Testing Laboratory Services Furnished by CONTRACTOR.
   2. OWNER'S Testing Agency Scope:
      a. Test CONTRACTOR'S proposed materials in the laboratory and/or field for compliance with the Specifications.
      b. Perform field moisture content and density tests to assure that the specified compaction of backfill materials has been obtained.
      c. Report all test results to the ENGINEER and CONTRACTOR.
   3. Authority and Duties of OWNER'S Testing Agency: Technicians representing the testing laboratory shall inspect the materials in the field and perform tests and shall report their findings to the ENGINEER and CONTRACTOR. When

the materials furnished or Work performed fails to fulfill Specification requirements, the technician will direct the attention of the ENGINEER and CONTRACTOR to such failure.

a. The technician shall not act as foreman or perform other duties for CONTRACTOR. Work will be checked as it progresses, but failure to detect any defective Work or materials shall not in any way prevent later rejection when such defect is discovered, nor shall it obligate the ENGINEER for final acceptance. Technicians are not authorized to revoke, alter, relax, enlarge, or release any requirements of the Contract Documents, nor to approve or accept any portion of the Work.

4. Responsibilities and Duties of CONTRACTOR:
   a. The use of testing services shall in no way relieve CONTRACTOR of the responsibility to furnish materials and construction in full compliance with the Contract Documents.
   b. To facilitate testing services:
      1) Secure and deliver to the ENGINEER or to the testing agency, without cost, preliminary representative samples of the materials he proposes to use and which are required to be tested.
      2) Furnish such casual labor as is necessary to obtain and handle samples at the Work site or at other sources of material.
      3) Advise the OWNER'S testing agency at least two days in advance of any backfill operations to allow for completion of quality tests and for the assignment of personnel.
   c. CONTRACTOR'S Testing Service shall inspect and approve subgrades and fill layers before further construction Work is performed thereon.
   d. Responsibility belongs to CONTRACTOR to accomplish the specified compaction for backfill, fill, and other earthwork, and to control his operations by confirmation tests to verify and confirm that CONTRACTOR has complied, and is complying at all times, with the requirements of these Specifications concerning compaction, control, and testing.
   e. The frequency of CONTRACTOR'S confirmation tests shall be not less than as follows; each test location for trenches shall include tests for each layer, type, or class of backfill from bedding to finish grade.
      1) Trenches for structures, and underground ductbanks:
         a) In open fields: Two locations every 1,000 linear feet.
         b) Along dirt or gravel roads or off traveled right-of-way: Two locations every 500 linear feet.
         c) Crossing paved roads: Two locations along each crossing.
         d) Under pavement cuts or within two feet of pavement edges: One location every 400 linear feet.
      2) For structural backfill: On 30-foot intervals on all sides of the structure for every compacted lift but no less than one per lift on each side of the structure for structures less than 60 feet long on a side.
      3) In embankment or fill: One per 1000 square feet on every compacted lift.

4) Base material: One per 1000 square feet on every compacted lift.
5) Footing Subgrade: For each strata of soil on which footings will be placed, conduct at least one test to verify required design bearing capacities. Subsequent verification and approval of each footing subgrade may be based on a visual comparison of each subgrade with related tested strata, when acceptable to ENGINEER.
6) Paved Areas and Building Slab Subgrade: Make at least one field density test of subgrade for every 500 square feet of paved area or building slab, but in no case less than three tests. In each compacted fill layer, make one field density test for every 1000 square feet of overlaying building slab or paved area, but in no case less than three tests.
7) Foundation Wall Backfill: Take at least two field density tests, at locations and elevations as directed by the ENGINEER.

f. Copies of the test reports shall be submitted promptly to the ENGINEER. CONTRACTOR'S tests to be performed by a soils testing laboratory acceptable to the ENGINEER.
g. Demonstrate the adequacy of compaction equipment and procedures before exceeding any of the following amounts of earthwork quantities:
1) 200 linear feet of trench backfill.
2) 10 cubic yards of structural backfill.
3) 100 cubic yards of embankment work.
4) 50 cubic yards of base material.
h. Until the specified degree of compaction on the previously specified amounts of earthwork is achieved, no additional earthwork of the same kind shall be performed.
i. Periodic compliance tests will be made by the ENGINEER to verify that compaction is conforming to the requirements previously specified, at no cost to CONTRACTOR. Remove the overburden above the level at which the ENGINEER wishes to test and shall backfill and recompact the excavation after the test is complete.
j. If compaction fails to conform to the specified requirements, remove and replace the backfill at proper density or shall bring the density up to specified level by other means acceptable to the ENGINEER. Subsequent tests required to confirm and verify that the reconstructed backfill has been brought up to specified density shall be paid by CONTRACTOR. CONTRACTOR'S confirmation tests to be performed in a manner acceptable to the ENGINEER. Frequency of confirmation tests for remedial Work shall be double that amount specified for initial confirmation tests.

B. Permits and Regulations:
1. Obtain all necessary permits for Work in roads, rights-of-way, railroads, etc. Also, obtain permits as required by local, state and federal agencies for discharging water from excavations.

2. Perform excavation Work in compliance with applicable requirements of governing authorities having jurisdiction.

C. Reference Standards: Comply with applicable provisions and recommendations of the following, except as otherwise shown or specified.
1. ASTM A 36, Specification for Structural Steel.
2. ASTM A 328, Specification for Steel Sheet Piling.
3. ASTM D 422, Method for Particle-Size Analysis of Soils.
4. ASTM D 427, Test Methods for Shrinkage Factors of Soils by the Mercury Method.
5. ASTM D 698, Test Method for Laboratory Compaction Characteristics of Soil.
6. ASTM D 1556, Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.
7. ASTM D 2166, Test Method for Unconfined Compressive Strength Of Cohesive Soils.
8. ASTM D 2922, Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
9. ASTM D 4318, Test Method for Liquid Limit, Plastic Limit and Plasticity Index of Soils.
10. AISC Specifications for the Design, Fabrication, and Erection of Structural Steel for Buildings.
11. OSHA Standard, Title 29, Code of Federal Regulations, Part 1926, Section .650 (Subpart P - Excavations).
12. Phoenix Building Code.
13. Uniform Standard Specifications for Public Work Construction by the Maricopa Association of Governments (MAG) as supplemented by the City of Phoenix, Section 206, Structure Excavation and Backfill, Section 604, Placement of Controlled Low Strength Material, Section 702, Base Materials, Section 725, Portland Cement Concrete, Section 728, Controlled Low Strength Material. Where there is a conflict between MAG Standard Specifications as supplemented by the City of Phoenix and this Specification, provisions of this Specification shall govern.

1.3 SUBMITTALS

Shop Drawings: Submit for approval the following:
1. Excavation and Backfill Submittals:
   a. Excavation Plan: Prior to start of excavation operations, a written plan shall be submitted to demonstrate compliance with OSHA Standard 29 CFR Part 1926.650. As a minimum, excavation plan shall include:
      1) Name of competent person.
      2) Excavation method(s) or protective system(s) to be used.
      3) Copies of "manufacturer's data" or other tabulated data if protective system(s) are designed on the basis of such data.

a. Excavation and backfill requirements detailing sheeting and bracing, or other protective system(s), dewatering systems, cofferdams, and underpinning.
b. Shop Drawings shall be prepared by a Registered Professional Engineer, licensed in the State of Arizona, recognized as an expert in the specialty involved. Drawings shall be submitted to ENGINEER for record purposes only. Calculations shall not be submitted. Drawing submittals will not be checked and will not imply approval by ENGINEER of the Work involved. Sole responsibility for designing, installing, operating and maintaining whatever system is necessary to satisfactorily accomplish all necessary sheeting, bracing, protection, underpinning and dewatering belongs to CONTRACTOR.
c. Samples of all materials, including select backfill, general backfill, crushed stone and sand shall be submitted to the ENGINEER and the testing service. Samples of the proposed material shall be submitted at least 14 days in advance of its anticipated use.

1. Test Reports:
   a. Testing laboratory shall submit copies of the following reports directly to ENGINEER, with copy to CONTRACTOR:
      1) Tests on borrow material.
      2) Tests on footing subgrade.
      3) Field density tests.
      4) Optimum moisture - maximum density curve for each soil used for backfill.
      5) Tests of actual unconfined compressive strength or bearing tests of each strata.
      6) Reports of observations for conformance of borrow material to the Project Geotechnical Report.

1.4 JOB CONDITIONS

A. Subsurface Information: Refer to Section 00700, General Conditions, and Section 00800, Supplementary Conditions, for available data on subsurface conditions. The data is not intended as a representation or warranty of continuity of conditions between soil borings nor of groundwater levels at dates and times other than date and time when measured. OWNER will not be responsible for interpretations or conclusions by CONTRACTOR. Data is solely made available for the convenience of CONTRACTOR.
   1. Additional test borings and other exploratory operations may be made by CONTRACTOR, at no additional cost to OWNER.
   2. Refer to and comply with the requirements of Section 02220, Demolitions.

B. Existing Structures: The Drawings show certain surface and underground structures adjacent to the Work. This information has been obtained from existing records. It is not guaranteed to be correct or complete and is shown on the Drawings for the

convenience of CONTRACTOR. Explore ahead of the required excavation to determine the exact location of all existing structures. Structures shall be supported and protected from damage by CONTRACTOR. If they are broken or damaged, restore them immediately, at no additional cost to the OWNER.

C. Existing Utilities: Locate existing underground utilities in the areas of the Work. If utilities are to remain in place, provide adequate means of protection during all operations.
   1. Should uncharted or incorrectly charted piping or other utilities be encountered during excavation, consult piping or utility owner and ENGINEER immediately for directions as to procedure. Cooperate with OWNER and utility owner in keeping services and facilities in operation. Repair damaged utilities to satisfaction of utility owner.
   2. In general, service lines to individual houses and businesses are not shown on the Drawings, however, assume that a service exists for each utility to each house or business.
   3. Do not interrupt existing utilities serving facilities occupied and used by OWNER or others, except when permitted in writing by ENGINEER and then only after acceptable temporary utility services have been provided.
   4. Demolish and completely remove from site existing underground utilities indicated to be removed. Coordinate with utility companies for shut-off of services if lines are active.

D. Use of Explosives:
   1. The use of explosives will not be permitted.
   2. Do not bring explosives onto site or use in the Work without prior written permission from authorities having jurisdiction. Provide copy of authorization to ENGINEER. Sole responsibility for handling, storage, and use of explosive materials when their use is permitted belongs to CONTRACTOR.

E. Protection of Persons and Property: Barricade open excavations occurring as part of the Work and post with warning lights. Operate warning lights during hours from dusk to dawn each day and as otherwise required.
   1. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout and other hazards created by earthwork operations.

F. Dust Control: Conduct all operations meeting the requirements specified in Section 01414, Earthmoving and Dust Control.

G. Roadways and Walks: Unless otherwise approved by ENGINEER, excavated material and materials of construction shall be so deposited, and the Work shall be so conducted, as to leave open and free for pedestrian traffic all crosswalks, and for vehicular traffic a roadway not less than ten feet in width. All hydrants, valves, fire alarm boxes, letter boxes, and other facilities which may require access during

construction shall be kept accessible for use. During the progress of the Work, maintain such crosswalks, sidewalks, and roadways in satisfactory condition and the Work shall at all times be so conducted as to cause a minimum of inconvenience to public travel, and to permit safe and convenient access to private and public property along the line of the Work.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

A. Backfill and Fill Materials:
   1. Materials acceptable for use as backfill against walls, foundations, underground ductbanks, and other structures shall be stockpiled native sandy clay or granular soils obtained from on-site excavations and which are uniformly mixed, contain no organic matter, nor contain rocks or fragments greater than 4-inches in size, nor have greater than 40 percent passing the 200 sieve. The maximum expansion of on-site materials shall be 1.5 percent as performed on a sample remolded to approximately 95 percent of the maximum dry density as determined in accordance with ASTM D 698 at two percent below optimum moisture content under a 100 psf surcharge pressure.
   2. Backfill and fill materials from off-site sources shall consist of silty or clayey sand soils which are uniformly mixed, contain no organic matter and which have a Plasticity Index less than ten. The maximum particle size of imported soils shall be 4-inches or less, if required to satisfy trenching, landscaping, or other requirements. The maximum expansion of off-site materials shall be 1.5 percent as performed on a sample remolded to approximately 95 percent of the maximum dry density as determined in accordance with ASTM D 698 at two percent below optimum moisture content under a 100 psf surcharge pressure.
   3. All materials for use as backfill and fill material shall be tested by the laboratory and approved by the ENGINEER.
   4. Material shall be considered unsuitable for fill, subgrade, shoulders and other uses if it contains organic matter, soft spongy earth, or other matter of such nature that compaction to the specified density is unobtainable.
      a. If on-site material is unsuitable as determined by the ENGINEER, select backfill or approved off-site fill shall be used.
   5. Fill adjacent to structures is classified as backfill to a distance measured horizontally from the structure that is equal to the depth from the finished grade. Outside these limits the fill is classified as embankments, unless otherwise specified.
   6. Refer to and comply with the requirements of Section 02319, Riprap.

B. Select Backfill: Select Backfill for use beneath concrete slabs and asphaltic pavements shall be crushed aggregate conforming to the requirements below:

Sieve Sizes (Square Openings)	Percentage by Weight Passing Sieve
1-1/4-inch	100
No. 4	38 to 65
No. 8	25 to 60
No. 30	10 to 40
No. 200	3 to 12

C. Fill Material for Embankments:
   1. Fill materials for use as embankments, and as miscellaneous landscaping materials exterior to plant facilities, shall consist of soils obtained from on-site excavations or off-site sources that are uniformly mixed, contain no organic material, rocks or fragments greater than 3-inches in size.
   2. All materials for use as described above shall be tested by the laboratory and approved by the ENGINEER.

D. Drainage Fill: Washed, uniformly graded mixture of crushed stone, or crushed or uncrushed gravel, with 100 percent passing a 1-1/2 inch sieve and not more than five percent passing a No. 4 sieve. Crushed stone or gravel shall be crushed rock or gravel conforming to the requirements of Section 02318, Crushed Stone and Gravel.

E. General Backfill and Fill Materials: Provide approved soil materials for backfill and fill, free of clay, rock or gravel larger than 6-inches in any dimension, debris, waste, frozen materials, vegetable and other organic matter and other deleterious materials. Previously excavated materials meeting these requirements may be used for backfill.

F. Imported Borrow Material: Imported borrow shall consist of material required for construction and unless otherwise designated in the special provisions, the Contractor shall make arrangements for obtaining imported borrow and shall pay all costs involved. When designated sources for imported borrow are indicated on the plans, in the special provisions, the material shall be assumed approved by the Engineer.
   1. Borrow material for fill within the roadway prism shall meet the following requirements:
      a. The Plasticity Index (PI) (AASHTO T-90) and the percent passing the number 200 sieve (Minus 200) (ASTM C136) when used in the equation below, shall give a value of X that does not exceed 62.
      b. X = (Minus 200) + 2.83 (PI)
      c. When the percentage of the Minus 200 material is greater than 30, the PI for the soil shall be at least 5 and at the same time in compliance with the X value requirement.
      d. The material shall be free from wood, vegetation, or other deleterious matter. The maximum size of this material shall not be greater than 2/3 the compacted thickness of the course placed in the subgrade.

e. The Contractor shall notify the Engineer sufficiently in advance of opening any material sites so that cross-section elevations and measurements of the ground surface after stripping may be taken and sufficient time for testing and material will be allowed.

2. Borrow pits shall be excavated to regular lines to permit accurate measurement; depth of excavation throughout the area of borrow pits shall be as uniform as practicable and the side slope shall be dressed to such slope as may be directed, leaving the borrow pit area in a clean and safe condition.

PART 3 -EXECUTION

3.1 INSPECTION

A. Provide ENGINEER with sufficient notice and with means to examine the areas and conditions under which excavating, filling, and grading are to be performed. The CONTRACTOR to call for a final inspection by the ENGINEER of all components to be buried and comply with the inspection recommendations. ENGINEER will notify CONTRACTOR if conditions are found that may be detrimental to the proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions have been corrected in an acceptable manner.

3.2 SITE PREPARATION

A. Clear all areas to be occupied by permanent construction or embankments of all trees, brush, roots, stumps, logs, wood and other materials and debris. Clean and strip subgrades for fills and embankments of vegetation, sod, topsoil and organic matter. All waste materials shall be removed from site and properly disposed of by CONTRACTOR. Burning is not permitted. Refer to and comply with the requirements of Section 02230, Clearing.

3.3 TEST PITS

A. General:
   1. Excavate and backfill, in advance of the construction, test pits to determine conditions or location of the existing utilities and structures. Perform all Work required in connection with excavating, stockpiling, maintaining, sheeting, shoring, backfilling and replacing pavement for the test pits.
      a. Responsibility for the definite location of each existing facility involved within the area of his excavation for Work under this Contract belongs to CONTRACTOR. Care shall be exercised during such location work to avoid damaging and/or disrupting the affected facility. Responsibility for repairing, at his expense, damage to any structure, piping, or utility caused by his Work, belongs to CONTRACTOR.

B. No separate payment will be made for test pits shown on the Drawings.

C. Payment for test pits ordered by ENGINEER will be paid for under the unit price bid.

D. No separate payment will be made for test pits made by CONTRACTOR for his own use.

3.4 EXCAVATION

A. Perform all excavation required to complete the Work as shown on the Drawings, specified and required. Excavations shall include earth, sand, clay, gravel, hardpan, boulders not requiring drilling and blasting for removal, decomposed rock, pavements, rubbish and all other materials within the excavation limits, except rock.

B. Excavations for structures and underground ductbanks shall be open excavations. Provide excavation protection system(s) required by ordinances, codes, law and regulations to prevent injury to workmen and to prevent damage to new and existing structures or pipelines. Unless shown on the Drawings or specified otherwise, protection system(s) shall be utilized under the following conditions.
   1. Excavation Less Than Five Feet Deep: Excavations in stable rock or in soil conditions where there is no potential for a cave-in may be made with vertical sides. Under all other conditions, excavations shall be sloped and benched, shielded, or shored and braced.
   2. Excavations More Than Five Feet Deep: Excavations in stable rock where there is no potential for a cave-in may be made with vertical sides. Under all other conditions, excavations shall be sloped and benched, shielded or shored and braced.
   3. Excavation protection system(s) shall be installed and maintained in accordance with drawings submitted under Article 1.3, above.

C. Where the structure or ductbank is to be placed below the ground water table, well points, cofferdams or other acceptable methods shall be used to permit construction of said structure under dry conditions. Dry conditions shall prevail until concrete has reached sufficient strength to withstand earth and hydrostatic loads. In addition, protect excavation from flooding until all walls and floor framing up to and including grade level floors are in place and backfilling has begun. Water level shall be maintained below top of backfill at all times.

D. Pumping of water from excavations shall be done in such a manner to prevent the carrying away of unsolidified concrete materials, and to prevent damage to the existing subgrade.

E. The elevation of the bottom of footings shown on the Drawings shall be considered as approximate only and ENGINEER may order such changes in dimensions and elevations as may be required to secure a satisfactory footing. All structure

excavations shall be hand-trimmed to permit the placing of full widths, and lengths of footings on horizontal beds. Rounded and undercut edges will not be permitted.

F. When excavations are made below the required grades, without the written order of ENGINEER, they shall be backfilled with select backfill material, as directed by ENGINEER, at the expense of CONTRACTOR.

G. Excavations shall be extended sufficiently on each side of structures, footings, etc., to permit setting of forms, installation of shoring or bracing or the safe sloping of banks.

H. Subgrades for roadways and structures shall be firm, dense, and thoroughly compacted and consolidated; shall be free from mud, muck, and other soft or unsuitable materials; and shall remain firm and intact under all construction operations. Subgrades which are otherwise solid, but which become soft or mucky on top due to construction operations, shall be reinforced with select backfill material. The finished elevation of stabilized subgrades shall not be above subgrade elevations shown on the Drawings. Proof roll all subgrades prior to placing of select fill and general fill material.

I. Material Storage: Stockpile satisfactory excavated materials in approved areas, until required for backfill or fill. Place, grade and shape stockpiles for proper drainage.
   1. Locate and retain soil materials away from edge of excavations.
   2. Dispose of excess soil material and waste materials as specified hereinafter.
   3. Stockpiled excavated soils for use as subsequent fill shall be classified by laboratory as on-site granular or sandy clay soils. Use and placement of fill shall be performed as specified for each class.
   4. Excess soil from excavations shall be disposed of off-site. Disposal shall be in accordance with state and local regulatory requirements.

J. Where ENGINEER considers the existing material beneath the bedding material unsuitable, CONTRACTOR remove same and replace it with select backfill.

K. Material shall be considered unsuitable for fill, subgrade, shoulders and other uses if it contains organic matter, soft spongy earth, or other matter of such nature that compaction to the specified density is unobtainable.

3.6 UNAUTHORIZED EXCAVATION

A. All excavation outside the lines and grades shown on the Drawings, and which is not approved by ENGINEER, together with the removal and disposal of the associated material shall be at CONTRACTOR'S expense. Unauthorized excavations shall be filled and compacted with select backfill by CONTRACTOR at his expense.

3.7 DRAINAGE, EROSION CONTROL AND DEWATERING

A. Erosion Control:
   1. In general, the construction procedures outlined herein shall be implemented to assure minimum damage to the environment during construction. Take any and all additional measures required to conform to the requirements of applicable codes and regulations, and the requirements specified in Section 01412, Stormwater Pollution Prevention Plan and Permit.
   2. Whenever possible, access and temporary roads shall be located and constructed to avoid environmental damage. Provisions shall be made to regulate drainage, avoid erosion and minimize damage to vegetation.
   3. Where areas must be cleared for storage of materials or temporary structures, provisions shall be made for regulating drainage and controlling erosion, subject to the ENGINEER'S approval.
   4. Temporary measures shall be applied to control erosion and to minimize the silting of the existing waterways, and natural ponding areas. Such measures shall include, but are not limited to, the use of berms, baled straw silt barriers, gravel or crushed stone, mulch, slope drains and other methods. These temporary measures shall be applied to erodible materials exposed by any activities associated with the construction of this Work.
      a. Special care shall be taken to eliminate depressions that could serve as mosquito pools.
      b. Temporary measures shall be coordinated with the construction of permanent drainage facilities and other Work to the extent practicable to assure economical, effective, and continuous erosion and silt control.
      c. Provide special care in areas with steep slopes. Disturbance of vegetation shall be kept to a minimum to maintain stability.
   5. Remove only those shrubs and grasses that must be removed for construction. Protect the remainder to preserve their erosion-control value.
   6. Install erosion and sediment control practices where shown on the Drawings and according to applicable standards, codes and specifications. The practices shall be maintained in effective working condition during construction and until the drainage area has been permanently stabilized.
   7. Mulching to be used for temporary stabilization.
      a. Suitable Materials for Mulching:
         1) Unrotted straw or salt hay: 1-1/2 to 2 tons/acre.
         2) Asphalt emulsion or cutback asphalt: 600 to 1200 gal. /acre.
         3) Wood-fiber or paper-fiber (hydroseeding): 1500 lbs./ acre.
         4) Mulch netting (paper, jute, excelsior, cotton or plastic).
      b. Straw or salt hay mulches should be immediately anchored using peg and twine netting or a mulch anchoring tool or liquid mulch binders.
   8. After stabilization, remove all straw bale dikes, debris, etc., from the site.
   9. In the event of any temporary Work stoppage, take steps any temporary or environmental damage to the area undergoing construction.

10. In the event CONTRACTOR repeatedly fails to satisfactorily control erosion and siltation, the OWNER reserves the right to employ outside assistance or to use its own forces to provide the corrective measures indicated. The cost of such work, plus engineering costs, will be deducted from monies due CONTRACTOR.
11. Prevent blowing and movement of dust from exposed soil surfaces and access roads to reduce on and off-site damage and health hazards. Control may be achieved by irrigation in which the site shall be sprinkled with water until the surface is moist. The process shall be repeated as needed.

B. Drainage and Dewatering:
   1. Provide and maintain adequate drainage and dewatering equipment to remove and dispose of all surface water and ground water entering excavations, or other parts of the Work. Each excavation shall be kept dry during subgrade preparation and continually thereafter until the structure to be built, therein is inspected by the ENGINEER and backfill operations have been completed and approved.
      a. The different working areas on the site shall be kept free of surface water at all times. Install drainage ditches and dikes and shall perform all pumping and other Work necessary to divert or remove rainfall and all other accumulations of surface water from the excavations and fill areas. The diversion and removal of surface water shall be performed in a manner that will prevent the accumulation of water behind temporary structures or at any other locations within the construction area where it may be detrimental.
      b. Water used for working or processing, resulting from dewatering operations, or containing oils or sediments that will reduce the quality of the water downstream of the point of discharge, shall not be directly discharged. Such waters shall be diverted through a settling basin or filter before being discharged.
      c. Responsibility belongs to CONTRACTOR for the condition of any pipe, conduit or channel used for drainage purposes and all such pipes, conduits or channels shall be left clean and free of sediment.
      d. Remove water from excavations as fast as it collects.
   2. Provide, install and operate sufficient trenches, sumps, pumps, hose, piping, well points, deep wells, etc., necessary to depress and maintain the ground water level below the base of the excavations during all stages of construction operations. The ground water table shall be lowered in advance of excavation, for a sufficient period of time so as to permit dewatering of fine grain soils, and maintained two feet below the lowest subgrade excavation made until the structure has sufficient strength and weight to withstand horizontal and vertical soil and water pressures from natural ground water. The system shall be operated on a 24-hour basis and standby pumping facilities and personnel shall be provided to maintain the continued effectiveness of the system. If, in the opinion of the ENGINEER, the water levels are not being lowered or maintained

as required by these Specifications, install additional or alternate dewatering devices as necessary, at no additional cost to the OWNER.

a. Elements of the system shall be located so as to allow a continuous dewatering operation without interfering with the construction of the permanent Work. Where portions of the dewatering system are located in the area of permanent construction, submit details of the methods he proposes to construct the permanent Work in this location for the approval of the ENGINEER. Controls of ground water shall continue until the permanent construction provides sufficient dead load to withstand the hydrostatic uplift of the normal ground water, until concrete has attained sufficient strength to withstand earth and hydrostatic loads, and until all waterproofing Work has been completed. Dispose of all water removed from the excavation in such a manner so as not to endanger any portion of the Work under construction or completed. Convey water from the excavations in a closed conduit. Before discontinuing dewatering operations or permanently permitting the rise of the ground water level, computations shall be made to show that any structure affected by the water level rise is protected by backfill or other means to sustain uplift. Use a safety factor of 1.25 when making these computations.

b. Dewatering operations shall not be discontinued without the prior authorization of the ENGINEER.

c. Design of dewatering system, including both drawings and calculations, shall be performed by a Registered Professional Engineer in the State of Arizona and shall be employed by CONTRACTOR. Dewatering system shall be designed so as to avoid settlement or damage to existing structures and utilities.

3. SRP may release water from upstream dams into the Salt and Gila Rivers which may affect ground water levels on the project site.

C. Disposal of Water Removed by Dewatering System:

1. CONTRACTOR'S Dewatering System may be discharged to the Lift Station 66 wet well as long as flows do not exceed 1mgd and disposal is in accordance with State and Federal regulations.
2. Dispose of all water removed from the excavation in such a manner as not to endanger public health, property, or any portion of the Work under construction or completed.
3. Dispose of water in such a manner as to cause no inconvenience to OWNER, ENGINEER, or others involved in Work about the site.
4. Convey water from the construction site in a closed conduit. Do not use trench excavations as temporary drainage ditches
5. Meter the quantity of water discharged in a manner acceptable to the Arizona Department of Water Resources.
6. The discharged water from the Dewatering System shall be purchased from the Arizona Department of Water Resources at the prevailing rate.

3.8 SHEETING, SHORING AND BRACING FOR STRUCTURE EXCAVATIONS

A. General:
   1. Used material shall be in good condition, not damaged or excessively pitted. All steel or wood sheeting designated to remain in place shall be new. New or used sheeting may be used for temporary work.
   2. All timber used for breast boards (lagging) shall be new or used, meeting the requirements for Douglas Fir Dense Construction grade with a bending strength not less than 1500 psi or Southern Pine No. 2 Dense.
   3. All steel work for sheeting, shoring, bracing, cofferdams etc., shall be designed in accordance with the provisions of the "Specifications for the Design, Fabrication and Erection of Structural Steel for Buildings", of the AISC except that field welding will be permitted.
   4. Steel sheet piling shall be manufactured from steel conforming to ASTM A 328. Steel for soldier piles, wales and braces shall be new or used and shall conform to ASTM A 36.
   5. Maintain shoring and bracing in excavations regardless of time period excavations will be open. Carry down shoring and bracing as excavation progresses.
   6. Unless otherwise shown on the Drawings, specified, or ordered, all materials used for temporary construction shall be removed when Work is completed. Such removal shall be made in a manner not injurious to the structure or its appearance or to adjacent Work.
   7. Provide permanent steel sheet piling or pressure creosoted timber sheet piling wherever subsequent removal of sheet piling might permit lateral movement of soil under adjacent structures. Cut off tops as required, but at least three feet below grade, and leave permanently in place.
   8. The clearances and types of the temporary structures, insofar as they affect the character of the finished Work, and the design of sheeting to be left in place, will be subject to the approval of ENGINEER; but responsibility for the adequacy of all sheeting, shoring, bracing, coffer-damming, etc., belongs to CONTRACTOR.
   9. Safe and satisfactory sheeting, shoring and bracing shall be the entire responsibility of CONTRACTOR.
   10. All municipal, County, State and Federal ordinances, codes, regulations and laws shall be observed.

B. Sheeting Left in Place:
   1. Steel sheet piling shown on the Drawings to be left in place shall consist of rolled sections of the continuous interlocking type, unless otherwise approved. The type and design of the sheeting and bracing shall conform to the above specifications for all steel work for sheeting and bracing. Steel sheeting designated to be left in place shall be new.
   2. Steel sheet piling to be left in place shall be driven straight to the lines and grades as shown on the Drawings or directed. The piles shall penetrate into firm

materials with secure interlocking throughout the entire length of the pile. Damaged piling having faulty alignment shall be pulled and replaced by new piling.

3. The type of guide structure used and method of driving for steel sheet piling to be left in place shall be subject to the approval of ENGINEER. Jetting will not be permitted.
4. Cut off piling left in place to the grades shown on the Drawings or directed by ENGINEER and remove the cut offs from the site.
5. Clean wales, braces and all other items to be embedded in the permanent structure, and ensure that the concrete surrounding the embedded element is sound and free from air pockets or harmful inclusions. Provisions shall include the cutting of holes in the webs and flanges of wale and bracing members, and the welding of steel diaphragm waterstops perpendicular to the centerline of brace ends which are to be embedded.
6. Subsequent to removal of the inside face forms, and when removal of bracing is permitted, cut back steel at least 2-inches inside the wall face and patch opening with cement mortar. Concrete shall be thoroughly worked beneath wales and braces, around stiffeners and in any other place where voids may be formed.
7. Portions of sheeting or soldier piles and breast boards which are in contact with the foundation concrete shall be left in place, together with wales and bracing members which are cast into foundation or superstructure concrete.

C. Removal of Sheeting and Bracing:
   1. Remove sheeting and bracing from excavations, unless otherwise directed in writing by ENGINEER. Removal shall be done so as to not cause injury to the Work. Removal shall be equal on both sides of excavation to ensure no unequal loads on pipe or structure.
   2. Defer removal of sheeting and bracing, where removal may cause soil to come into contact with concrete, until the following conditions are satisfied:
      a. Concrete has cured a minimum of seven days.
      b. Wall and floor framing up to and including grade level floors are in place.

3.9 TRENCH SHIELDS

A. Excavation of earth material below the bottom of a shield shall not exceed the limits established by ordinances, codes, laws and regulations.

B. When using a shield for the installation of structures, the bottom of the shield shall not extend below the top of the bedding for the structures.

C. When a shield is removed extreme care shall be taken to prevent damage to the structures or the disturbance of the bedding for structures. Structures that are disturbed shall be removed and reinstalled as specified.

3.10 PLACEMENT OF FILL AND BACKFILL

A. General:
   1. All select backfill and backfill required for structures, embankments, and ductbanks and required to provide the finished grades shown on the Drawings and as described herein shall be furnished, placed and compacted by CONTRACTOR. Refer to and comply with the requirements of Section 02318, Crushed Stone and Gravel.
   2. Backfill excavations as promptly as Work permits, but not until completion of the following:
      a. Acceptance by the ENGINEER of construction below finish grade, including dampproofing, waterproofing and perimeter insulation.
      b. Inspection, testing, approval, and recording of locations of underground ductbanks.
      c. Removal of concrete formwork.
      d. Removal of shoring and bracing, and backfilling of voids with satisfactory materials.
      e. Removal of trash and debris.
   3. Fill containing organic materials or other unacceptable material shall be removed and replaced with approved fill material as specified.

B. Placement of Select Backfill, Backfill and Fill:
   1. Select backfill shall be placed to the grades shown on the Drawings. The lift thickness and compaction moisture content range given herein are approximate. These values shall be finally determined from the laboratory test results on the fill materials. Testing requirements shall be as specified in Paragraph 3.9.E., below.
   2. All select backfill shall be placed in horizontal loose lifts, not exceeding 8-inches in thickness, and shall be mixed and spread in a manner assuring uniform lift thickness after placing. Each lift shall be compacted by not less than two complete coverages of the specified compactor. Select backfill shall be placed to the underside of all concrete slabs. The fill material shall extend a minimum of two feet outside the face of each structure and be 12-inches below finished grade on all structures. The maximum slope of select backfill to the subgrade shall be one vertical to one horizontal.
   3. Backfill and fill around and outside of structures and over select backfill shall be deposited in layers not to exceed 8-inches in uncompacted thickness and mechanically compacted, using platform type tampers. Compaction of structures backfilled by rolling will be permitted provided the desired compaction is obtained and damage to the structure is prevented. Compaction of select backfill and/or backfill by inundation with water will not be permitted. All materials shall be deposited as specified herein and as shown on the Drawings.
   4. The material shall be placed at a moisture content and density as specified under Paragraph 3.9.E., below. Provide equipment capable of adding measured amounts of water to the backfill and/or select backfill material to bring it to a

condition within the range of the required moisture content. Provide equipment capable of discing, aerating, and mixing the soil to ensure reasonable uniformity of moisture content throughout the fill material and to reduce the moisture content of the borrow material by air drying, if necessary. If the subgrade or lift of earth material must be moisture conditioned before compaction, the fill material shall be sufficiently mixed or worked on the subgrade to ensure a uniform moisture content throughout the lift of material to be compacted. Materials at moisture content in excess of the specified limit shall be dried by aeration or stockpiled for drying.

5. No backfill or fill material shall be placed when free water is standing on the surface of the area where the fill is to be placed. No compaction of fill will be permitted with free water on any portion of the fill to be compacted. No fill shall be placed or compacted in a frozen condition or on top of frozen material. Any fill containing organic materials or other unacceptable material previously described shall be removed and replaced with approved fill material prior to compaction.
6. Compaction shall be performed with equipment suitable for the type of fill material being placed. Select equipment that is capable of providing the minimum density required by these Specifications. Hand operated compacting equipment shall be used within a distance of ten feet from the wall of any completed below grade structure. Equipment shall be provided that is capable of compacting in restricted areas next to structures and around piping. The effectiveness of the equipment selected shall be tested at the commencement of compacted fill Work by construction of a small section of fill within the area where fill is to be placed. If tests on this section of fill show that the specified compaction is not obtained, increase the amount of coverages, decrease the lift thicknesses and/or obtain a different type of compactor.
7. Levels of backfill against concrete walls shall not differ by more than two feet on either side of walls, unless walls are adequately braced or all floor framing is in place up to and including grade level slabs. Particular care shall be taken to compact structure backfill, which will be beneath pipes, roads, or other surface construction or structures. In addition, wherever a trench passes through structure backfill, the structure backfill shall be placed and compacted to an elevation 12-inches above the top of the pipe before the trench is excavated. Compacted areas, in each case, shall be adequate to support the item to be constructed or placed thereon.
8. The compaction requirements specified are predicated on the use of normal materials and compaction equipment. In order to establish criteria for the placement of a controlled fill so that it will have compressibility and strength characteristics compatible with the proposed structural loadings, a series of laboratory compaction and/or compressive strength tests shall be performed on the samples of materials submitted by CONTRACTOR. From the results of the laboratory tests, the final values of the required percent compaction, the acceptable compaction moisture content range, and the maximum permissible

lift thickness will be established for the fill material and construction equipment proposed.

9. Control the water content of fill material during placement within the range necessary to obtain the compaction specified. In general, the moisture content of the fill shall be within three percent of the optimum moisture content for compaction as determined by laboratory tests. Perform all necessary work to adjust the water content of the material to within the range necessary to permit the compaction specified. Do not place fill material when free water is standing on the surface of the area where the fill is to be placed. No compaction of fill will be permitted with free water on any portion of the fill to be compacted.
10. Compact fill shall be compacted by at least two coverages of all portions of the surface of each lift by compaction equipment. One coverage is defined as the condition obtained when all portions of the surface of the fill material have been subjected to the direct contact of the compactor.
11. If the specified densities are not obtained because of improper control of placement or compaction procedures, or because of inadequate or improperly functioning compaction equipment, perform whatever Work is required to provide the required densities. This Work shall include complete removal of unacceptable fill areas, and replacement and recompaction until acceptable fill is provided.
12. If any settlement occurs, repairs will be at CONTRACTOR'S expense. Make all repairs and replacements necessary within 30 days after notice from ENGINEER or OWNER.
13. Special attention is required to assure compaction under all piping to spring line, if the compaction process is not satisfactory to the ENGINEER. The CONTRACTOR shall use half-sack slurry for backfill to spring line.

C. Backfill in Electrical Ductbank Trenches:
   1. Compacted backfill shall be required for the full depth of the trench, below and above the electrical ductbank. Where the trench for one ductbank passes beneath the trench for another pipe or ductbank select backfill shall be placed to the level of the bottom of the upper trench.
   2. Placement and compaction of backfill in electrical ductbank trenches shall conform to the requirements of Paragraph 3.9.B., above.

D. Crushed Stone Placement:
   1. Crushed stone shall be placed where shown on the Drawings to the limits shown.
   2. Crushed stone shall be place in hand tamped lifts, not to exceed 6-inches.

E. Compaction Density Requirements:
   1. The degree of compaction required for all types of fills shall be as listed below. Material shall be moistened or aerated as necessary to provide the moisture content that will facilitate obtaining the specified compaction.

Material Thick.(in)	Required Minimum Density-Percent Compaction (ASTM D 698)	*Maximum Uncompacted Lift (inches)
Subgrade and Subbase Fill:		
Below concrete slabs on grade	95	8
Below base of footings or mats, structural slabs and tank floors	95	8
Below asphalt concrete paving	95	12
**Structural Backfill:		
More than 5 feet below final grade	100	8
Less than 5 feet below grade	95	8
Aggregate Base Course:		
Below concrete slabs or mats	95	8
Below asphalt paving	100	8
Trench Backfill, below and above ductbanks	95	12

* Where applicable.

** Structural backfill shall not be used for support of facilities which are susceptible to damage from differential settlement of the fill section relative to walls.

2. All fill must be wetted and thoroughly mixed to achieve optimum moisture content, ±three percent, with the following exceptions: On site clayey soils optimum to plus three percent.

3. Natural undisturbed soils or compacted soil subsequently disturbed or removed by construction operations shall be replaced with materials compacted as specified above.
4. CONTRACTOR'S testing service shall perform tests necessary to provide data for selection of fill material and control of placement water content.
5. Field density tests, to ensure that the specified density is being obtained, shall be performed by CONTRACTOR'S testing service during each day of compaction Work.
6. If the tests indicate unsatisfactory compaction, provide the additional compaction necessary to obtain the specified degree of compaction. All additional compaction Work shall be performed by CONTRACTOR, at no additional cost to the OWNER, until the specified compaction is obtained. This Work shall include complete removal of unacceptable (as determined by the ENGINEER) fill areas and replacement and recompaction until acceptable fill is provided.

F. Replacement of Unacceptable Excavated Materials: In cases where over-excavation for the replacement of unacceptable soil materials is required, the excavation shall be backfilled to the required subgrade with select backfill material and thoroughly compacted as specified in Paragraph 3.9.E., above. Sides of the excavation shall be sloped in accordance to the maximum inclinations specified for each structure location.

3.11 EMBANKMENTS

A. To the maximum extent available, use excess earth obtained from structure and underground ductbank excavations for construction of embankments. Obtain additional material from borrow pits as necessary. After preparation of the embankment area, level and roll the subgrade so that surface materials of the subgrade will be compact and well bonded with the first layer of the embankment. All material deposited in embankments shall be free from rocks or stones, brush, stumps, logs, roots, debris, and organic or other objectionable materials. Construct embankments in horizontal layers not exceeding 8-inches in uncompacted thickness. Spread and level material deposited by excavating and hauling equipment prior to compaction. Thoroughly compact each layer by rolling or other method acceptable to the ENGINEER to 95 percent of the maximum density at optimum moisture content as determined by ASTM D 698. If the material fails to meet the density specified, compaction methods shall be altered. Wherever an excavation passes through a fill or embankment, the fill or embankment material shall be placed and compacted to an elevation 24-inches above the top of the trench before trench is excavated.

3.12 GRADING

A. General: Uniformly grade areas within limits of grading under this Section, including adjacent transition areas. Smooth subgrade surfaces within specified tolerances, compact with uniform levels or slopes between points where elevations are shown on the Drawings, or between such points and existing grades.

B. Grading Outside Building Lines: Grade areas adjacent to building lines to drain away from structures and to prevent ponding. Finish surfaces free from irregular surface changes, and as follows:
   1. Turfed Areas or Areas Covered with Gravel, Stone, Wood Chips, or Other Special Cover: Finish areas to receive topsoil or special cover to within not more than 1-inch above or below the required subgrade elevations.
   2. Walks: Shape surface of areas under walks to line, grade and cross-section, with finish surface not more than 1-inch above or below the required subgrade elevation.
   3. Pavements: Shape surface of areas under pavement to line, grade and cross-section, with finish surface not more than 1/2-inch above or below the required subgrade elevation.

C. Grading Surface of Fill Under Building Slabs: Grade smooth and even, free of voids, compacted as specified, and to required elevation. Provide final grades within a tolerance of 1/2-inch when tested with a ten foot straightedge.

D. Compaction:
   1. After grading, compact subgrade surfaces to the depth and percentage of maximum density for each area classification.

3.13 PAVEMENT SUBBASE COURSE

A. General: Place subbase material, in layers of specified thickness, over ground surface to support pavement base course.
   1. Refer to Section 02742, Bituminous Paving, for paving Specifications.

B. Grade Control: During construction, maintain lines and grades including crown and cross-slope of subbase course.

C. Shoulders: Place shoulders along edges of base course to prevent lateral movement. Construct shoulders of acceptable soil materials, placed in such quantity to compact to thickness of each base course layer. Compact and roll at least a 12-inch width of shoulder simultaneously with compacting and rolling of each layer of base course.

D. Placing: Place base course material on prepared subgrade in layers of uniform thickness, conforming to indicated cross-section and thickness. Maintain optimum moisture content for compacting base material during placement operations.
   1. When a compacted base course is shown on the Drawings to be 6-inches thick or less, place material in a single layer. When shown on the Drawings to be more than 6-inches thick, place material in equal layers, except no single layer more than 6-inches or less than 3-inches in thickness when compacted.

3.14 DISPOSAL OF EXCAVATED MATERIALS

A. Material removed from the excavations which does not conform to the requirements for fill or is in excess of that required for backfill shall be hauled away from the project site by CONTRACTOR and disposed of in compliance with ordinances, codes, laws and regulations at no additional cost to the OWNER. Refer to and comply with the requirements of Section 02230, Clearing.

3.15 RESTORING AND RESURFACING EXISTING ROADWAYS AND FACILITIES

A. Place 1-1/2 inches of temporary bituminous pavement immediately after backfilling trenches in paved roadways which are to be retained for permanent use. Maintain the surface of the paved area over the trench in good and safe condition during progress of the entire Work, and promptly fill all depressions over and adjacent to

the trench caused by settlement of backfilling. The permanent replacement pavement shall be equal to that of the existing roadways, unless otherwise specified.

B. Pavement, gutters, curbs, sidewalks or roadways disturbed or damaged by the CONTRACTOR'S operations, except areas designated "New Pavement" or "Proposed Pavement", shall be restored by CONTRACTOR at his own expense to as good condition as they were previous to the commencement of the Work and in accordance with applicable local and state highway specifications.

3.16 PRECONSOLIDATION

A. Where shown on the Drawings, preconsolidate soils prior to construction. These areas shall be brought up to finished grade a minimum of three months prior to the start of construction of the structures situated thereon. If any settlement occurs during this period, the settled area shall be promptly brought up to grade by the placement of additional fill.

B. After the topsoil has been stripped, settlement plates shall be placed where shown on the Drawings and specified.

C. Fill material to be placed over the preconsolidation areas and the method of placement shall be as specified under Article 3.10, above. Should removal of 6-inches of topsoil result in a subgrade elevation below the base slab of proposed structures, the remaining topsoil and other unacceptable material shall be removed until suitable subgrade materials are exposed. The subgrade shall then be brought up to the proposed base slab elevation with special compacted fill.

D. Settlement plates for the observation of subsoil consolidation under fill loads shall be installed at the locations, and furnished in accordance with the details shown on the Drawings. Level the areas occupied by settlement plates so that the base of each plate will be at an elevation approximately equivalent to the average ground surface within a radius of five feet from the plate location. All small depressions in the ground surface at the plate location shall be filled with sand before seating the plate. The installed plate shall include the first five foot pipe section tightly seated in the base coupling with the pipe marked at one foot intervals measured from the base of the plate. All marks on this and subsequent sections shall be painted with high visibility paint. The uppermost mark shall be permanently recorded by cutting a horizontal slot into the pipe with a hacksaw exactly five feet above the base of the plate. The installation of the settlement plate and its marking shall be approved by ENGINEER before placement of the 6-inch sand cover to anchor the plate as shown on the Drawings. Subsequent to approval, establish the elevation of the base of the plate by determining the elevation of the uppermost mark on the pipe section.

E. During the filling operations, add five foot sections of pipe to the settlement plate as required to maintain the top of the pipe above the fill surface at all times. When pipe

sections are added, they shall be tightly joined and the additional section marked by painting at one foot intervals and including a hacksaw slot exactly five feet above the hacksaw slot made in the previous pipe section. The addition of all settlement plate extensions shall be approved by the ENGINEER before fill placement resumes in the area.

F. Provide barricades around the settlement plate extensions to protect them from damage during construction. In the event that a plate is damaged by the construction operations, replace or repair it in a manner satisfactory to ENGINEER.

G. Measure and record the elevation of the settlement plate and the elevation of the fill surface at the plate location once each week after the plates are installed and submit these data to ENGINEER.

H. Do not start construction of structures situated on areas to be preconsolidated until sufficient settlement has occurred. The degree of settlement considered sufficient shall be determined by ENGINEER from readings of settlement plates.

I. In no case shall construction commence within three months of fill placement.

J. Prior to topsoiling and seeding, the filled area shall be cut back and graded to the proper subgrade, if necessary.

3.17 PIEZOMETERS

A. Prior to the start of excavation, install piezometer at locations shown on the Drawings.

B. Each piezometer shall consist of a 1/2-inch diameter pipe equipped with a well point screen in the bottom three feet, and placed in a five foot length of sand packing at the bottom of a bore hole with a five foot long grout seal above the sand packing as follows: A boring to receive the piezometer shall be extended to the bedrock surface and cased for its entire length. After the boring is completed, clean wash water shall be circulated until the return water is clear of fines. The bottom foot of the bore hole shall be backfilled with clean concrete sand. The well point screen and a length of 1/2-inch diameter pipe, sufficient to reach from the top of the sand backfill to ground surface, shall be lowered to the previously placed sand with its well point screen end down and centered in the casing while the space surrounding the pipe is backfilled with additional clean concrete sand for a length of four feet above the tip of the well point. During all the backfilling operations, the casing shall be withdrawn in small increments so as to avoid disturbing the backfill but without exposing the sides of the hole above the backfill at any time. After tamping the sand backfill and while the 1/2-inch diameter pipe is centered in the casing a 4 to 3 to 1 mixture by volume of fine sand, cement and bentonite shall be poured around the pipe to fill a five foot length above the sand backfill. The casing shall be removed from this depth

immediately after pouring the grout. The 1/2-inch diameter pipe shall be fitted with a threaded cap having a 1/8-inch diameter opening at the top. The elevation of the top of the pipe shall be determined by CONTRACTOR. Test fill each piezometer after installation to determine by the response to filling that the device is operative. The test filling shall be repeated at regular intervals during the Work.

C. Each piezometer shall be accessible for reading at all stages of the Work. If necessary, the riser pipe may be shortened as excavation progresses; however, after each shortening the top of the pipe shall be rethreaded and the elevation of the top redetermined. Maintain the piezometers at least until the structure base is completed. However, do not remove a piezometer without approval of ENGINEER. Any piezometer which is damaged or destroyed or becomes inoperative shall be repaired or replaced at CONTRACTOR'S expense.

D. Record the water level in each piezometer and submit the data to ENGINEER at least once each day after the piezometers are installed.

3.18 TEMPORARY FENCING

A. Furnish and install a temporary fence surrounding his excavations and Work area, including the stockpile and storage areas. Fence shall have openings only at vehicular, equipment and worker access points.

B. Furnish and install a temporary screening fence as shown on the Drawings.

3.19 ENVIRONMENTAL PROTECTION AND RESTORATION

A. Refer to and comply with the requirements of Section 01412, Stormwater Pollution Prevention Plan and Permits.

+ + END OF SECTION + +

SECTION 02319

RIPRAP

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals required to furnish and place riprap at locations shown on the Drawings and specified.
   2. Any existing riprap removed shall be replaced by CONTRACTOR at no additional cost to the OWNER.

1.2 QUALITY ASSURANCE

A. Conform to all applicable requirements of Section 703 in the Uniform Standard Specifications for Public Works Construction by the Maricopa Association of Governments (MAG) as supplemented by the City of Phoenix. If there is a conflict between the MAG Standard Specifications, as supplemented by the City of Phoenix, and these Specifications, the provisions in these Specifications shall govern.

PART 2 - PRODUCTS

2.1 MATERIAL

A. Stone for riprap shall be sound and durable, free from seams and coatings, and of such characteristics that it will not disintegrate when subjected to the action of water.

B. Riprap stone shall be as large as can be conveniently placed in a layer of the required depth. The stones, excepting small stones and spalls used chink interstices shall weigh not less than ten pounds and at least 50 percent of the stone shall not weigh less than 100 pounds.

C. Waste concrete may be used if the pieces are sound free from coatings and meet the size specified for a stone. Stones salvaged from excavation and meeting the above requirements may be used for riprap, if approved by the ENGINEER.

PART 3 - EXECUTION

3.1 PLACING

A. Minimum total thickness of the riprap layer shall be 8 inches.

B. The stones shall be placed so that the weight of the stone is carried by the underlying material and not by the adjacent stones. On slopes, the largest of stones shall be at

the bottom. Riprap shall be of proper size to form a compact solid blanket to protect the slopes. Rounded boulders or cobbles shall not be used on slopes steeper than 2 to 1, unless grouted.

C. Riprap shall be placed so as to conform as closely as practicable in size and character to existing riprap, if applicable.

D. Riprap may be placed in location by equipment, however, care shall be taken in placing to obtain a good gradation of materials so that the riprap will be firm and solid. Surfaces shall be leveled to the required alignment and slopes by hand placing the stone so as to fill large voids and to make the surface even.

+ + END OF SECTION + +

SECTION 02742

BITUMINOUS PAVING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish and install hot mix hot-laid bituminous paving.
   2. The Work includes the following:
      a. Preparation of subgrade.
      b. Coarse graded base course.
      c. Fine graded surface course.
      d. Pavement marking.
      e. Testing as specified.

1.2 QUALITY ASSURANCE

A. Standard Specifications and Details:
   1. Conform to all applicable requirements of the Uniform Standard Specifications For Public Works Construction by the Maricopa Association of Governments (MAG) as supplemented by the City of Phoenix as follows:
      a. Section 321, Asphalt Concrete Pavement.
      b. Section 702, Base Materials.
      c. Section 703, Emulsified Asphalts.
      d. Section 710, Asphalt Concrete.
   2. If there is a conflict between the MAG Standard Specifications as supplemented by the City of Phoenix and these Specifications, the provisions of these Specifications shall govern.
   3. City of Phoenix, Streets and Traffic Department Standard Specifications.
      a. S.S.P-2 - Water-Bourne Traffic Binder Paint.

B. Reference Standards: Comply with the applicable provisions and recommendations of the following, unless otherwise shown or specified.
   1. ASTM C 117, Test Method for Materials Finer than No. 200 Sieve in Mineral Aggregates By Washing.
   2. ASTM C 136, Test Method for Sieve Analysis of Fine And Coarse Aggregates.
   3. ASTM D 698, Test Methods for Laboratory Compaction Characteristics of Soil using Standard Effort (12,400 ft-lbf/ft^3).
   4. MAG Standard Specifications, Section 321, as supplemented by the City of Phoenix.
   5. MAG Standard Specifications, Section 702, as supplemented by the City of Phoenix.

6. MAG Standard Specifications, Section 710, as supplemented by the City of Phoenix.
7. Standard Specification S.S.P.-2, City of Phoenix Streets and Traffic Department.

C. Testing Services:
   1. General: Testing of materials and of compaction requirements for compliance with technical requirements of the Specifications shall be the duty of a testing laboratory provided by the OWNER, as described in Section 01451, Testing Laboratory Services Furnished by OWNER. Determination and testing of the proposed design mix for the hot-mix course shall be performed by a testing laboratory provided by CONTRACTOR, as described in Section 01452, Testing Laboratory Services Furnished by CONTRACTOR.
   2. Testing Services: The OWNER'S testing laboratory shall:
      a. Test CONTRACTOR'S proposed materials in the laboratory and field for compliance with the requirements of these Specifications.
      b. Perform field density tests to assure that the specified compaction of base course materials has been obtained.
      c. Report all test results to the ENGINEER and CONTRACTOR.
   3. Authority and Duties of OWNER'S Testing Laboratory: Technicians representing the testing laboratory shall inspect the materials in the field and perform compaction tests, and shall report their findings to the ENGINEER and CONTRACTOR. When the materials furnished or Work performed by the CONTRACTOR fails to fulfill Specifications requirements, the technician shall direct the attention of the ENGINEER and CONTRACTOR to such failure.
      a. The technician shall not act as foreman or perform other duties for CONTRACTOR. Work will be checked as it progresses, but failure to detect any defective Work or materials shall not in any way prevent later rejection when such defect is discovered, nor shall it obligate the ENGINEER for final acceptance. Technicians are not authorized to revoke, alter, relax, enlarge, or release any requirements of the Specifications, nor to approve or accept any portion of the Work.
   4. Responsibilities and Duties of CONTRACTOR: The use of testing services shall in no way relieve CONTRACTOR of his responsibility to furnish materials and construction in full compliance with the Contract Documents. To facilitate testing services:
      a. Secure and deliver to the ENGINEER and the testing laboratory representative samples of the materials he proposes to use and which are required to be tested.
      b. Furnish such casual labor as is necessary to obtain and handle samples at the project or at other sources of material.
      c. Advise the testing laboratory and ENGINEER sufficiently in advance of operations to allow for completion of quality tests and for the assignment of personnel.

D. Pre-Paving Meeting:
   1. Prior to the placement of Bituminous Paving, arrange a meeting at the job-site with the paver and its foreman, general CONTRACTOR and its foreman, ENGINEER and other representatives directly concerned with placement. Record the discussions of the conference and the decisions and agreements (or disagreements) and furnish a copy of the record to each party attending. Review foreseeable methods and procedures relating to the paving work, including but not necessarily limited to, the following:
      a. Review Project requirements, including Contract Documents, Project Schedule, approved Shop Drawings, pending and approved Change Orders and requests for information that may have been submitted by CONTRACTOR to ENGINEER.
      b. Review required samples, submittals, and documentation procedures.
      c. Review sub grade preparation
      d. Review availability of materials, tradesman, equipment and facilities needed to make progress, avoid delays and protect the Work from damaging conditions.
      e. Review required inspection, testing, certifying and quality control procedures.
      f. Review weather and forecasted weather conditions, and procedures for coping with unfavorable conditions.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. City of Phoenix Type 1 mix, giving complete data on materials, including source, location, percentages, temperatures and all other pertinent data.
   2. The submittal shall be reviewed by the ENGINEER and OWNER.

B. Material Certificates:
   1. In lieu of laboratory reports required in the State Standards, CONTRACTOR may submit certificates of compliance for the following:
      a. Coarse and fine aggregates from each material source and each required grading.
      b. Asphalt for each penetration grade.
      c. Job-mix design mixtures for each material or grade.
      d. Density of uncompacted bituminous concrete.
      e. Density of compacted bituminous concrete.
      f. Density and voids analysis for each series of bituminous concrete mixture test specimens.
      g. Bituminous concrete plant inspection.
   2. Certificates that materials, mixtures and plant comply with Specification requirements.
   3. Certificates signed by CONTRACTOR.

1.4 JOB CONDITIONS

A. Weather Limitations:
   1. For base paving 2-inches thick or greater, atmospheric temperature shall be 40°F and rising. For surface paving or pavement less than 2-inches thick, the surface temperature shall be 50°F or greater.
   2. No asphalt concrete shall be placed when the weather is foggy or rainy, or when the base on which the material is to be placed contains moisture in excess of the optimum. Asphalt concrete shall be placed only when the ENGINEER determines that weather conditions are suitable.

B. Grade Control: Establish and maintain the required lines and grades, including crown and cross-slope for each course during construction operations.

PART 2 - PRODUCTS

2.1 PAVEMENT THICKNESS

A. Provide a minimum of 2-inch compacted premixed base course and minimum of 1.5-inch compacted surface course for a total compacted depth of 3.5)-inches or according to thickness detailed on the Drawings for pavement where shown on the Drawings.
B. All sides of the asphalt area shall be curbed flush with edge of asphalt, unless otherwise shown on the drawings, to retain the asphalt during placement and protect edges from damage by heavy equipment.

2.2 MATERIALS

A. Base Course:
   1. Base course material shall be a 1/2-inch hot mix asphalt concrete, consisting of a mixture of mineral aggregate and paving asphalt conforming to Section 710 of the MAG Standard Specifications. Gradation of the aggregate shall comply with the City of Phoenix Type 1.
   2. The City of Phoenix Type 1 asphalt shall contain a minimum of 1.5 percent cement and 5.5 percent oil.

B. Surface Course:
   1. Surface course material shall be a 1/2-inch hot mix asphalt concrete, consisting of mineral aggregate and paving asphalt conforming to Section 710 of the MAG Specifications. Gradation of the aggregate shall comply with the City of Phoenix Type 1.
   2. The City of Phoenix Type 1 asphalt shall contain a minimum of 1.5 percent cement and 5.5 percent oil.

C. Tack Coat: The tack coat shall be emulsified asphalt Type SS-1h according to MAG 329, unless directed otherwise by the ENGINEER.

2.3 TRAFFIC AND PARKING MARKING MATERIALS

A. Traffic and parking marking materials shall be a water based paint conforming to the City of Phoenix Streets and Traffic Department Operations Division Specification S.S.P-2, Water-Bourne Traffic Binder Paint. Refer to paragraph 1.2.A.3.

PART 3 - EXECUTION

3.1 INSPECTION

A. Examine the subgrade on which bituminous concrete will be installed. Notify ENGINEER, in writing, of conditions detrimental to the proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions have been corrected in a manner acceptable to ENGINEER.

B. No materials shall be placed on subgrades, which are muddy or have water thereon.

3.2 CONSTRUCTION OF ROADWAYS

A. General:
   1. The pavement for bituminous-surfaced roads and parking areas shall consist of a 6-inch base course composed of aggregates and bituminous material, mixed hot in a central plant, and constructed on an aggregate base course prime coated with a rapid curing paving asphalt. A surface course shall also be applied where shown on the Drawings.
   2. The roadways shall be constructed to the lines, grades, and typical sections shown on the Drawings.

B. Base and Surface Course:
   1. The base course mixture shall be transported to the site of paving and placed as soon as possible after mixing.
   2. The placement of the base course shall be completed over the full width of the section under construction on each day's run.
   3. Asphalt base and surface courses shall be spread and finished by means of self-propelled mechanical spreading and finishing equipment. The compacted thickness of layers placed shall not exceed 150 percent of the specified thickness except as approved, in writing, by the ENGINEER.
   4. Sufficient rolling equipment shall be furnished to satisfactorily compact and finish the amount of mixture being placed. However, there shall be a minimum of two rollers with two operators on the Project at all times. Upon direction of the ENGINEER, one of the rollers may be a pneumatic-tire roller. During rolling operations, the speed of the roller(s) shall not exceed three miles per hour. If ample number of rollers are not present, adjust the asphalt placement rate to accommodate the roller(s) speed. The type and required number of rollers shall be on the Project and in acceptable operating condition, prior to the placement of any asphalt material. All rollers shall be operated continuously

from the breakdown through finish rolling. CONTRACTOR may use vibratory rollers in lieu of the steel-wheeled roller, however when the thickness of the asphalt is 1-inch or less, all rolling will be done in the static mode.

5. When more than one width of asphalt concrete material will be placed, a 6-inch strip adjacent to the area on which future material is to be laid shall not be rolled until such material has been placed but shall not be left unrolled more than two hours after being placed, unless the 6-inch unrolled strip is first heated with a joint heater. After the first strip or width has been compacted, the second width shall be placed, finished and compacted as provided for the first width, except that rolling shall be extended to include the 6-inches of the first width not previously completed.
6. At any place not accessible to the roller, the mixture shall be thoroughly compacted with tampers and finished, where necessary, with a hot smoothing iron to provide a uniform and smooth layer over the entire area compacted in this manner.
7. Breakdown rolling shall begin as soon as the mixture will bear the roller without undue displacement. Rolling shall be longitudinal, overlapping on successive trips by at least 1/2 but not more than 3/4 the width of the rear wheels. Alternate trips of the roller shall be of slightly different lengths. The motion of the roller shall at all time be slow enough to avoid displacement of the mixture. Finish rolling shall be done by means of a steel-wheeled roller or a vibratory steel-wheel roller operating in the static mode.

C. Tack Coat:
1. A tack coat shall be applied to all existing and to each new course of bituminous surfaces prior to the placing of a succeeding layer of bituminous mixed material. The tack coat may be deleted when a succeeding layer of asphalt concrete is being applied over a freshly laid course that has been subjected to very little traffic when approved by the ENGINEER.
2. The same material that is specified above for the tack coat shall be applied to the vertical surfaces of existing pavements, curbs, and gutters, against which asphalt concrete is to be placed.
3. Tack coat shall be diluted in the proportion of 50 percent emulsion and applied at the rate of 0.05 to 0.10 gallons per square yard. Application shall be made in advance of subsequent construction as directed by the ENGINEER.
4. Tack coat shall be applied by pressure-type distributor trucks with insulated tanks. Hand spray by means of hose or bar through a gear pump or air tank shall be acceptable for resurface work, corners or tacking of vertical edges. Care shall be taken to provide uniform coverage. Equipment that performs unsatisfactory shall be removed from the job.

D. Construction Joints:
1. Construction joints shall be made in such a manner as to ensure a neat junction, thorough compaction and bond throughout.
2. A transverse joint extending over the full width of the strip being laid and at right angles to its centerline shall be constructed at the end of each day's work

and at any other times when the operations of placing the hot mixture are suspended for a period of time which will permit the mixture to chill. The forward end of a freshly laid strip shall be thoroughly compacted by rolling before the mixture has become chilled. When Work is resumed, the end shall be cut vertically for the full depth of the layer.

E. Joining of Pavements: When pavement is to join existing or previously laid pavement, the existing or previously laid pavement shall be neatly and carefully edged to allow for overlapping and feathering of the surface course material. A tack coat of bituminous prime coat material shall be placed at the interface of pavement and existing or previously laid pavement.

F. Curing: The pavement shall not be opened to traffic until directed by the ENGINEER. Construction traffic on the pavement shall be held to a minimum as allowed by the ENGINEER.

3.3 FRAME ADJUSTMENT

A. Set frames of drainage structures to final grade in an approved manner. Include existing frames and frames furnished under other Sections of these Specifications. Comply with requirements of Section 02771, Concrete Curbs, Gutters and Sidewalks.

3.4 PAVEMENT QUALITY REQUIREMENTS

A. General: In addition to other specified conditions, comply with the following minimum requirements:
   1. Provide final surfaces of uniform texture, conforming to required grades and cross sections.
   2. Take not less than one 4-inch diameter pavement specimen for each complete course for each 10,000 square feet of pavement, unless directed by ENGINEER.
   3. Repair holes from test specimens as specified for patching defective Work.

B. Density:
   1. If directed by ENGINEER, compare density of in-place material against laboratory specimen or certificates on same bituminous concrete mixture. Use nuclear devices.
   2. Minimum acceptable density of in-place course material shall be 90 percent of the recorded laboratory specimen or certificate density. Maximum acceptable density shall be 98 percent.

C. Thickness: In-place compacted thicknesses shall average not less than the thicknesses specified.

D. Surface Smoothness:
   1. Test finished surface of each bituminous concrete course for smoothness, using a ten foot straightedge applied parallel to and at right angles to centerline of paved areas.
   2. Check surfaced areas at intervals as directed by ENGINEER.
   3. Surfaces will not be acceptable if exceeding the following:
      a. Base Course: 3/8-inch in ten feet.
      b. Surface Course: 1/4-inch in ten feet.
      c. Crowned Surfaces:
         1) Test crowned surfaces with a crown template, centered and at right angles to the crown.
         2) Surfaces will not be acceptable if varying more than 1/4-inch from the template.

3.5 PATCHING

A. As directed by ENGINEER, remove and replace all defective areas. Cut-out such areas and fill with fresh bituminous concrete. Compact to the required density.

3.6 CLEANING AND PROTECTION

A. Cleaning: After completion of paving operations, clean surfaces of excess or spilled bituminous materials and all foreign matter.

B. Protect newly finished pavement until it has become properly hardened by cooling.

C. Cover openings of drainage structures in the area of paving until permanent coverings are placed.

3.7 MARKING PAVEMENT

A. Cleaning:
   1. Sweep surface with power broom supplemented by hand brooms to remove loose material and dirt.
   2. Do not begin marking bituminous concrete pavement until approved by ENGINEER.

B. Application:
   1. Using mechanical equipment, provide uniform straight edges in two separate coats. Apply in accordance with paint manufacturer's recommended rates. Refer to paragraph 1.2.A.3.

CITY OF PHOENIX – 2002 APPROVED ASPHALT PLANTS AND MIX PRODUCT CODES

MIX / PLANTS	A-1 1/2" 4.3% W/C (High Volume)	A-1 1/2" 4.8% W/C (High Volume)	C-3/4" 5.0% W/C (High Volume)	C-3/4" 5.5% W/C (High Volume)	D-1/2" 5.1% W/C (High Volume)	D-1/2" 5.6% W/C (High Volume)
Vulcan (All Plants)	814325	814825	835025	835525	845125	845625
New West Val Vista #152	25AP152	25RP152	19AP152	19RP152	12AP152	12RP152
New West Sun City #302	25AP302	25RP302	19AP302	19RP302	12AP302	12RP302
New West Avondale #402	25AP402	25RP402	19AP402	19RP402	12AP402	12RP402
Mesa – East #1	732	741	535	544	431	438
Mesa – Sun #2	732	741	535	544	431	438
UM #10131 (01)	14301D	14801D	35001D	35501D	45101D	45601D
UM #10231 (02)	14302E	14801E	35001E	35501E	45101E	45601E
UM #11131 (11)	14301A	14801A	35004A	35504A	45103A	45601A
UM #11231 (12)	14302B	14801B	35003B	35504B	45101B	45602B
UM #14131 (41)	14301J	14801J	35002J	35504J	54101J	45601J

+ + END OF SECTION + +

SECTION 02771

CONCRETE CURBS, GUTTERS AND SIDEWALKS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish and install concrete curbs, gutters and sidewalks.
   2. Types of Work covered by this Section are as follows:
      a. Conventionally formed or machine formed curb.
      b. Conventionally formed or machine formed curb and gutter.
      c. Conventionally formed or machine formed curb and sidewalk.
      d. Conventionally formed or machine formed curb, gutter and sidewalk.
   3. The thickness and extent of curb, gutter and sidewalk as shown on the Drawings.

1.2 QUALITY ASSURANCE

A. Standard Specifications and Details:
   1. Conform to all applicable requirements of Section 340 of the Uniform Standard Specifications to Public Works Construction by the Maricopa Association of Governments (MAG) as supplemented by the City of Phoenix. If there is a conflict between MAG Standard Specifications as supplemented by the City of Phoenix and these Specifications, the Provisions of these Specifications shall govern.

B. Reference Standards: Comply with applicable provisions and recommendations of the following, except as otherwise shown or specified.
   1. ASTM D 1190, Specification for Concrete Joint Sealer, Hot Poured Elastic Type.

C. Applicator Qualifications: Minimum of two years installing curbs, gutters and sidewalks.

1.3 SUBMITTALS

A. Samples: Submit for approval the following:
   1. Samples, manufacturer's product data, test reports and material certifications as required in referenced Sections for concrete Work.

B. Certificates: Manufacturer's certification that sealer meets Specification requirements.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Reinforcing Bars and Welded Wire Fabric: Deformed steel bars and smooth wire fabric shall comply with requirements of Section 03200, Concrete Reinforcement.
   1. Furnish wire fabric in flat sheets, not rolls.

B. Concrete Materials: Comply with requirements of applicable Sections of Division 3, Concrete, for formwork, concrete materials, admixtures, bonding materials, curing materials and others as required.

C. Expansion Joint Material: Comply with requirements of Section 03251, Concrete Joints, for preformed expansion joint fillers.

2.2 CONCRETE MIX, DESIGN AND TESTING

A. Comply with requirements of applicable provisions of Section 03300, Cast-In-Place Concrete, for concrete mix design, sampling and testing, and quality control.

B. Design the mix to produce concrete having properties of compressive strength, slump range and air content as specified in Section 03300, Cast-In-Place Concrete.

PART 3 - EXECUTION

3.1 INSPECTION

A. Examine the substrate and the conditions under which Work is to be performed and notify ENGINEER, in writing, of unsatisfactory conditions. Do not proceed with the Work until unsatisfactory conditions have been corrected in a manner acceptable to ENGINEER.
B. Verify that earthwork is completed to correct line and grade.

C. Check that subgrade is smooth, compacted, and free of frost and excessive moisture.

D. Do not commence Work until conditions are satisfactory, and approved by ENGINEER.

3.2 POROUS FILL

A. Porous Fill Under Sidewalk: Furnish fill consisting of crushed stone, gravel, sand, or other approved material. Properly wet and compact fill to the thickness as shown on

the Drawings. Comply with requirements of Section, 02318, Crushed Stone and Gravel.

3.3 FORM CONSTRUCTION

A. Set forms to line and grade. Install forms over full length of curb, gutter and sidewalk.

3.4 REINFORCEMENT

A. Locate, place, and support reinforcement as specified in Section 03200, Concrete Reinforcement, unless otherwise shown on the Drawings. Size of reinforcement shall be as shown on the Drawings.

3.5 CONCRETE PLACEMENT

A. General: Comply with the requirements of Section 03300, Cast-In-Place Concrete, for mixing and placing concrete, and as specified.

B. Place concrete for curbs and gutters using methods which prevent segregation of the mix. Consolidate concrete along the face of forms with an internal vibrator.

C. For sidewalks, place concrete in one course, monolithic construction, for the full width and depth of walks.

D. Machine Formed: Automatic curb, gutter and sidewalk machine may be used for forming, at CONTRACTOR'S option. Concrete shall have properties as specified in Section 03300, Cast-In-Place Concrete, except that maximum slump shall be 2-1/2-inches and air content shall be two percent of design. Machine forming shall produce curbs, gutters and sidewalks to the required cross-section, lines, grades, finish, and jointing, as specified for conventionally formed concrete. If results do not conform to requirements remove and replace, at no additional cost to the OWNER.

3.6 JOINTS

A. General: Construct expansion, contraction, and construction joints with faces perpendicular to surface of the curb, gutter and sidewalk. Construct transverse joints at right angles to the Work centerline and as shown on the Drawings.

B. Contraction Joints: Provide these joints at ten feet on centers for curbs and gutters and five feet on centers for sidewalks.

C. Construction Joints: Place joints at locations where placement operations are stopped for a period of more than 1/2-hour, except where such pours terminate at expansion joints.

D. Expansion Joints: Provide 1/2-inch expansion joint filler where Work abuts structures; at returns; and at 30 foot spacing for straight runs. If curb, gutter, and sidewalk are not poured monolithically, provide expansion joints where each abuts the other.
   1. Place top of expansion joint material not less than 1/2-inch or more than 1-inch below concrete surface. Apply joint sealer on top of expansion joint material flush with concrete surface, and in accordance with manufacturer's instructions.

3.7 CONCRETE FINISHING

A. Smooth the exposed surface by screeding and floating.

B. Work edges of gutter and sidewalks back top edge of curb, and transverse joints; and round to 1/4-inch radius.

C. Complete surface finishing by drawing a fine-hair broom across surface, perpendicular to line of traffic.

3.8 CURING

A. Protect and cure finished concrete curbs, gutters and sidewalks, complying with applicable requirements of Section 03300, Cast-In-Place Concrete.

3.9 REPAIR AND CLEANING

A. Repair or replace broken or defective curbs, gutters and sidewalk as directed by the ENGINEER.

B. Sweep Work and wash free of stains, discolorations, dirt and other foreign material.

+ + END OF SECTION + +

SECTION 02981

DECORATIVE STONE LANDSCAPING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals required to furnish and install decorative stone landscaping as shown on the Drawings and specified.
   2. The types of decorative stone landscaping Work required include the following:
      a. Decomposed granite.
      b. Pre-emergent herbicide.
   3. The extent of the decorative stone landscaping shall be as shown on the Drawings.

B. Coordination:
   1. Review installation procedures under other Sections and coordinate the installation of items that must be installed with the decorative stone landscaping.

1.2 QUALITY ASSURANCE

A. Source Quality Control: Supply washed, screened, decomposed granite consisting of hard stone, free from coatings, obtained from a single source.

1.3 SUBMITTALS

A. Samples: Submit for approval the following:
   1. Selection of actual decorative stone available from the Supplier in individual, small polyethylene bags, for final selection by ENGINEER.
   2. Make available, for inspection and approval prior to placement of the material, a representative five pound sample of the decorative stone selected by ENGINEER, from the approved supply source.

B. Shop Drawings: Submit for approval the name of intended decomposed granite source.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Decomposed Granite:
   1. Decomposed granite shall match the size and color of existing landscaping rock and shall be supplied from a single supply source, for a uniform appearance

throughout the Project. It shall be free from lumps or balls of clay and shall not contain any calcareous coatings, caliche, organic matter or foreign substances.

PART 3 - EXECUTION

3.1 GENERAL

A. Decomposed granite shall be placed upon completion of construction and upon ENGINEER'S approval of all fine grading, irrigation, and planting elements.

B. The areas to receive decomposed granite shall be relatively smooth. All rocks larger than 1-1/2-inches shall be removed and disposed of by CONTRACTOR.

C. Prior to placing decomposed granite, all areas to receive it shall be sprayed with a pre-emergent herbicide according to the manufacturer's recommendations. Do not spray herbicide on any areas designated to receive seeding.

3.2 CONTRACTOR'S INSPECTION

A. Examine the subgrade, verify the elevations, observe the conditions under which Work is to be performed, and notify the ENGINEER, in writing, of unsatisfactory conditions. Do not proceed with the Work until unsatisfactory conditions have been corrected in a manner acceptable to ENGINEER.

3.3 PREPARATION

A. Outline areas to receive decorative stone landscaping and secure ENGINEER'S acceptance before start of Work. Make minor adjustments as may be requested by the ENGINEER.

3.4 PLACEMENT

A. Place decomposed granite to all areas designated on the Drawings to a minimum depth of 2-inches.

B. The top surface of the 2-inch decomposed granite layer shall be a minimum of 1-inches below any adjacent pavement or other elements.

C. After placing, all slope areas which have received decorative stone landscaping shall be watered down and rolled with a hand roller to assure adequate compaction of the material. A second application of pre-emergent herbicide shall be applied according to the manufacturer's recommendations.

3.5 MAINTENANCE

A. Repair all erosion channels that may form as directed by the ENGINEER until Final Completion.

B. Keep decorative stone landscaping free of any foreign material including, but not limited to, soil, debris and weeds, until Final Completion.

3.6 ENGINEER'S INSPECTION

A. When the decorative stone landscaping Work is completed, including maintenance, the ENGINEER will inspect to determine acceptability.

B. Where inspected decorative stone landscaping Work does not comply with the requirements, replace rejected Work and continue specified maintenance until reinspected by the ENGINEER and determined to be acceptable.

+ + END OF SECTION + +

SECTION 03100

CONCRETE FORMWORK

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals as shown, specified and required to furnish and install concrete formwork. The Work also includes:
      a. Providing openings in formwork to accommodate the Work under this and other Sections and building into the formwork all items such as sleeves, anchor bolts, inserts and all other items to be embedded in concrete for which placement is not specifically provided under other Sections.

B. Coordination:
   1. Review installation procedures under other Sections and coordinate the installation of items that must be installed with the formwork.
   2. Coordinate formwork specifications herein with the requirements for finished surfaces specified in Section 03300, Cast-In-Place Concrete, and Section 03200, Concrete Reinforcement.

1.2 QUALITY ASSURANCE

A. Standard Specifications and Details:
   1. Conform to all applicable requirements of Section No. 505 of the Uniform Standard Specifications for Public Works Construction by the Maricopa Association of Governments (MAG) as supplemented by the City of Phoenix. Where there is conflict between MAG Standard Specifications as supplemented by the City of Phoenix and this Specification, provisions of this Specification shall govern.
   2. Examine the substratum and the conditions under which concrete formwork is to be performed, and notify the ENGINEER, in writing, of unsatisfactory conditions. Do not proceed with the Work until unsatisfactory conditions have been corrected in a manner acceptable to the ENGINEER.

B. Mock-Ups for Concrete Finishes: Provide formwork for mock-ups as required for finish work shown and specified for the Work. Place embedded materials in mock-up. Construct forms using facing materials such as form liners, where required, to provide specified finishes and to the requirements specified in Section 03300, Cast-In-Place Concrete. Obtain ENGINEER'S acceptance of each mock-up prior to the start of formwork. Do not remove mock-up(s) until directed by ENGINEER.

C. Reference Standards: Comply with applicable provisions and recommendations of the following, except as otherwise shown or specified. Where conflicts may occur between the reference standards, the more restrictive provisions shall apply.
   1. ACI 117, Standard Tolerances for Concrete Construction and Materials.
   2. ACI 301, Standard Specifications for Structural Concrete.
   3. ACI 347, Guide for Concrete Formwork.
   4. ASTM C 805, Test Method for Rebound Number of Hardened Concrete.
   5. US Product Standard, PS-1-83 for Construction and Industrial Plywood.

D. Allowable Tolerances:
   1. Construct formwork to provide completed concrete surfaces complying with tolerances specified in ACI 347, Chapter 3.3, except as otherwise specified.
   2. Architectural Finish Formwork: Offset at panel joints: 1/8-inch.

E. Install all formwork and accessories for all facilities in accordance with manufacturers' instructions.

1.3 SUBMITTALS

A. Samples:
   1. Plywood form material used for smooth form finish, 4-inch square minimum.
   2. Form liner section large enough to show two full repeating patterns, but not less than 12-inches square.
   3. Controlled permeability formwork liner material, 8-inch square, minimum.
   4. Form Liner Sample Panel:
      a. Indicate texture and surface pattern, required backing, form tie treatment, and treatment at liner panel joints. Use form material to be used in the Work.
      b. Size: 3 feet by 4 feet (minimum).

B. Shop Drawings:
   1. Submit for approval the following:
      a. Fabrication and erection drawings of architecturally finished concrete surfaces as shown or specified. Show the general construction of forms including jointing, special formed joints or reveals, form liner installation, rustication, location and pattern of form tie placement, and other items which affect the finished concrete visually. ENGINEER'S review will be for general architectural applications and features only. Design of formwork for structural stability and sufficiency is CONTRACTOR'S responsibility.
      b. Taper tie installation, removal, and hole repair materials and procedures.
   2. Submit for information purposes the following:
      a. Copies of manufacturer's data and installation instructions for proprietary materials, including form coatings, manufactured form systems, ties and accessories.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING

A. On delivery to job site, place materials in area protected from weather, in accordance with manufacturers' recommendations.

B. Store materials above ground on framework or blocking. Cover wood for forms and other accessory materials with protective waterproof covering. Provide for adequate air circulation or ventilation. Store materials in accordance with the manufacturers' recommendations.

C. Handle materials to prevent damage in accordance with the manufacturers' recommendations.

PART 2 - PRODUCTS

2.1 FORM MATERIALS

A. Forms for Smooth Finish Concrete:
   1. Unless otherwise shown or specified, construct formwork for smooth concrete surfaces with plywood, metal, metal-framed plywood-faced, or other panel type materials acceptable to ENGINEER, to provide continuous, straight, smooth as-cast surfaces with no wood grain or other surface texture imparted by the formwork. Furnish in largest practical sizes to minimize number of joints and to conform to joint system shown or specified. Provide form material with sufficient thickness to withstand pressure of newly placed concrete without bow or deflection.

B. Forms for Standard Finish Concrete:
1. Form concrete surfaces designated to have a standard formed finish with plywood, lumber, metal, or other acceptable material. Provide lumber that is dressed on at least two edges and one side.

C. Forms for Architecturally Finished Concrete:
   1. Form finish concrete surfaces with units of face design, size, arrangement, and configuration as shown or as required to meet Project's job mock-up requirements. Provide solid backing and form supports to ensure stability of form liners.
   2. Form Material: Overlaid plywood, U.S. Products Standard PS-1-83 for Construction and Industrial Plywood. B-B high density overlaid concrete form, Class I.
   3. Form Liners: Rigid PVC or fiberglass in pattern shown.
   4. Form Reuse: To be determined by ENGINEER at the time of installation.
   5. Rustication Joints: Rigid PVC in profile shown.
   6. Panel Joints: Conceal all joints behind rustication joints, unless approved by ENGINEER, in writing.

D. Cylindrical Columns and Supports:
   1. Form round-section members with paper or fiber tubes, constructed of laminated plies using water-resistant type adhesive with wax-impregnated exterior for weather and moisture protection. Provide units with sufficient wall thickness to resist loads imposed by wet concrete without deformation.
      a. Provide manufacturer's seamless units to minimize spiral gaps or seams.
      b. Provide manufacturer's standard plastic-lined-interior units.
   2. Fiberglass or steel forms may be used for cylindrical columns, if approved by ENGINEER.

E. Pan Forms:
   1. Provide new forms for concrete pan-type construction complete with covers and end closures to form a true, clean, smooth concrete surface. Design units for easy removal without damaging placed concrete. Block adjoining pan units as required to avoid lateral deflection of formwork during concrete placement and vibration. Provide standard or tapered ends.
   2. Exposed to view forms: Form joints are only acceptable in one-way joists at end caps and tapered end forms. Off set at form joints shall not exceed 1/8-inch.
   3. Factory fabricate pan form units to required sizes and shapes, of one of the following materials:
      a. Steel: Minimum of 16 gage, free of dents, irregularities sag and rust. Use only new pan forms and reuse only once, if in satisfactory condition and approved by ENGINEER.
      b. Glass-Fiber Reinforced Plastic: Molded under pressure with matched dies, 0.11-inch minimum wall thickness.
      c. Asphalt-Impregnated Corrugated Material: Treated for moisture resistance with factory-applied polyethylene coating, and with top and side cover joints taped where concrete is exposed.

F. Form Ties:
   1. Provide factory-fabricated, removable or snapoff metal form ties, designed to prevent form deflection, and to prevent spalling of concrete surfaces upon removal. Materials used for tying forms will be subject to approval of ENGINEER.
   2. Unless otherwise shown, provide ties so that portion remaining within concrete after removal of exterior parts is at least 1.5-inch from the outer concrete surface. Unless otherwise shown, provide form ties that will leave a hole no larger than 1-inch diameter in the concrete surface.
   3. Ties for exterior walls, below grade walls, and walls subject to hydrostatic pressure shall have waterstops.
   4. All ties shall leave a uniform, circular hole when forms are removed.
   5. Provide stainless steel form ties for planned exposed tie hole locations, where shown on the Drawings. When used, tiebreak back point shall be at least 1-inch from outer concrete surface.

6. Wire ties are not acceptable.

G. Form Coatings:
   1. Provide commercial formulation form-coating compounds that will not bond with, stain, nor adversely affect concrete surfaces, and will not impair subsequent treatment of concrete surfaces requiring bond or adhesion, nor impede the wetting of surfaces to be cured with water or curing compounds. For concrete surfaces, which will be in contact with potable water, the form coating shall be a mineral oil base coating.
   2. Manufacturers and Products
      a. Atlas Construction Supply; Bio-Guard.
      b. Cresset Chemical Company; Crete-Lease 20-VOC.
      c. Hill And Griffith; Grifcote LV-50 Plus.

H. Controlled Permeability Formwork (CPF) Liner:
   1. Surface densification shall be provided for wall surfaces, where shown on the Drawings, through the use of a CPF liner material which wicks water and trapped air away from the form surface.
   2. The CPF liner shall be a material such as Zemdrain MD2 as manufactured by E.I. DuPont, or equal. It shall have the following properties.
      a. Non-compressible under concrete pressure.
      b. Controlled pore size to permit drainage of excess water and air while retaining cement particles.
      c. Retains within its structure a minimum of 0.5 liters of water per square meter of material.
   3. The CPF liner shall improve the performance of the characteristics of the concrete as follows:
      a. Surface hardness: In tests performed in accordance with ASTM C 805, the mean rebound number calculated for the CPF face shall exceed that of the control face (cast using standard formwork without CPF liner and the same concrete mix and placement procedures) by a minimum of five rebound units.
      b. The surface shall have a uniform texture and shall be free of minor surface defects from trapped air.

I. Void Forms
   1. Void (carton) forms shall be made of corrugated fiberboard used to create a void space beneath grade beams and slabs on grade.
   2. Void forms shall have moisture resistant treated paper faces, be laminated with waterproof adhesive, and shall be biodegradable. They shall have an interior fabrication of uniform braced cellular configuration and shall be capable of sustaining a minimum working load of 1000 psf for a minimum of ten days after concrete is placed.
   3. Void forms shall be as manufactured by: Sheplers, SureVoid Products, or equal.

2.2 DESIGN OF FORMWORK

A. Design, erect, support, brace and maintain formwork so that it shall safely support vertical and lateral loads that might be applied, until such loads can be supported by the concrete structure. Carry vertical and lateral loads to ground by formwork system or in-place construction that has attained adequate strength for this purpose. Construct formwork so that concrete members and structures are of correct size, shape, alignment, elevation and position.

B. Design forms and falsework to include values of live load, dead load, weight of moving equipment operated on formwork, concrete mix, height of concrete drop, vibrator frequency, ambient temperature, foundation pressures, stresses, lateral stability, and other factors pertinent to safety of structure during construction.

C. Provide shores and struts with positive means of adjustment capable of taking up formwork settlement during concrete placing operations, using wedges or jacks or a combination thereof. Provide trussed supports when adequate foundations for shores and struts cannot be secured.

D. Support form facing materials by structural members spaced sufficiently close to prevent beyond tolerance deflection, in accordance with ACI 117. Fit forms placed in successive units for continuous surfaces to accurate alignment, free from irregularities and within allowable tolerances. For long span members without intermediate supports, provide camber in formwork as required for anticipated deflections resulting from weight and pressure of fresh concrete and construction loads.

E. Design formwork to be readily removable without impact, shock or damage to concrete surfaces and adjacent materials.

F. Provide formwork sufficiently tight to prevent leakage of cement paste during concrete placement. Solidly butt joints and provide backup material at joints as required to prevent leakage and fins.

G. Omit side forms of footings and place concrete directly against excavation only when formally requested by CONTRACTOR, in writing, and accepted by ENGINEER, in writing. When omission of forms is accepted, provide additional concrete required beyond the minimum design profiles and dimensions of the footings as detailed. No additional compensation will be made to CONTRACTOR for additional concrete required.

PART 3 - EXECUTION

3.1 INSPECTION

A. Examine the substrate and the conditions under which Work is to be performed and notify ENGINEER, in writing, of unsatisfactory conditions. Do not proceed

with the Work until unsatisfactory conditions have been corrected in a manner acceptable to ENGINEER.

3.2 FORM CONSTRUCTION

A. Construct forms complying with the requirements of ACI 347; to the exact sizes, shapes, lines and dimensions shown; as required to obtain accurate alignment, location and grades; to tolerances specified; and to obtain level and plumb work in finish structures. Provide for openings, offsets, keyways, recesses, moldings, rustications, reglets, chamfers, blocking, screeds, bulkheads, anchorages and inserts, and other features required. Use selected materials to obtain required finishes. Finish shall be as determined by approved mock-up or sample panel, if specified.

B. Fabricate forms for easy removal without damaging concrete surfaces. Provide crush plates or wrecking plates where stripping may damage cast concrete surfaces. Provide top forms for inclined surfaces where the slope is too steep to place concrete with bottom forms only. Kerf wood inserts for forming keyways, reglets, recesses, and the like, to prevent swelling and assure ease of removal.

C. Provide temporary openings where interior area of formwork is inaccessible for cleanout, for inspection before concrete placement, and for placement of concrete. Brace temporary closures and set tightly to forms to prevent loss of cement paste. Locate temporary openings on forms in locations as inconspicuous as possible, consistent with requirements of the Work. Form intersecting planes of openings to provide true, clean-cut corners, with edge grain of plywood not exposed as form for concrete.

D. Falsework:
   1. Erect falsework and support, brace and maintain it to safely support vertical, lateral and asymmetrical loads applied until such loads can be supported by in-place concrete structures. Construct falsework so that adjustments can be made for take-up and settlement.
   2. Provide wedges, jacks or camber strips to facilitate vertical adjustments. Carefully inspect falsework and formwork during and after concrete placement operations to determine abnormal deflection or signs of failure; make necessary adjustments to produce finished Work of required dimensions.

E. Forms for Smooth Finish Concrete:
   1. Do not use metal cover plates for patching holes or defects in forms.
   2. Provide sharp, clean corners at intersecting planes, without visible edges or offsets. Back joints with extra studs or girts to maintain true, square intersections.

3. Use extra studs, walers and bracing to prevent bowing of forms between studs and to avoid bowed appearance in concrete. Do not use narrow strips of form material that will produce bow.
4. Assemble forms so they may be readily removed without damage to exposed concrete surfaces.
5. Form molding shapes, recesses, rustication joints and projections with smooth-finish materials, and install in forms with sealed joints to prevent displacement.

F. Corner Treatment:
1. Form exposed corners of beams, walls, foundations, bases and columns to produce smooth, solid, unbroken lines, except as otherwise shown. Exposed corners shall be chamfered.
2. Form chamfers with 3/4-inch by 3/4-inch strips, unless otherwise shown, accurately formed and surfaced to produce uniformly straight lines and tight edge joints. Use rigid PVC chamfers for all architecturally formed concrete. Extend terminal edges to required limit and miter chamfer strips at changes in direction.
3. Reentrant and unexposed corners may be formed either square or chamfered.

G. Joints:
1. Comply with the requirements of Section 03251, Concrete Joints, of these Specifications for treatment of joints. Locate as shown and specified.

H. Openings and Built-In Work:
1. Provide openings in concrete formwork shown or required by other Sections. Refer to Paragraph 1.1.B., above, for the requirements of coordination.
2. Accurately place and securely support items to be built into forms.

I. Sealing Formwork:
1. All formwork joints shall be tight fitting or otherwise sealed to prevent loss of cement paste.
2. All formwork, which rests against concrete surfaces, shall be provided with a compressible gasket material between the concrete and edge of form to fill any irregularities and create a tight seal.

J. Cleaning and Tightening:
1. Thoroughly clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt or other debris just before concrete is to be placed. Retighten forms immediately after concrete placement, as required to eliminate cement paste leaks.

3.3 FORM COATINGS

A. Coat form contact surfaces with a non-staining form-coating compound before reinforcement is placed. Do not allow excess form coating material to

accumulate in the forms or to come into contact with surfaces which will be bonded to fresh concrete. Apply in compliance with manufacturer's instructions.

B. Coat steel forms with a non-staining, rust-preventative form oil or otherwise protect against rusting. Rust-stained steel formwork is not acceptable.

C. For concrete surfaces that will be in contact with potable water, the form coating shall be a mineral oil base coating.

D. Do not use form coatings on form surfaces covered with CPF liner material.

3.4 INSTALLATION OF EMBEDDED ITEMS

A. Set and build into the formwork, anchorage devices and other embedded items, shown, specified or required by other Sections. Refer to Paragraph 1.1.B., above, for the requirements of coordination. Use necessary setting drawings, diagrams, instructions and directions.

B. Edge Forms and Screeds Strips for Slabs:
   1. Set edge forms or bulkheads and intermediate screed strips for slabs to obtain required elevations and contours in the finished slab surface. Provide and secure units to support screeds.

3.5 CONTROLLED PERMEABILITY FORMWORK LINER

A. Where shown on the Drawings, install controlled permeability formwork (CPF) liner material in accordance with manufacturer’s instructions so that it entirely and continuously covers the formwork surface.

B. Form release agent shall not be used on forms lined with CPF liner. Any residual traces of release agent on previously used forms shall be removed prior to placing the liner.

C. All joints and seams in the CPF liner shall be taped with materials recommended by the manufacturer. The CPF liner shall be attached to the form surface at intermediate spacing so as to prevent buckles and ripples in the liner material when warmed by the fresh concrete placement. Spacing of attachments shall not exceed 24-inches.

D. All form panel edges shall be taped around the corner with materials recommended by the manufacturer. The edges of penetrations through the form, including form tie holes, shall be taped or otherwise sealed.

E. The CPF liner shall be permitted to be reused once without removal from the forms. When reused, the liner material shall be washed and all concrete or other foreign materials removed prior to reuse.

3.6 VOID FORMS

A. Install void forms where shown on the Drawings and to the thickness indicated in accordance with the manufacturer's recommendations.

B. Where void form is indicated, it shall be placed, to the grades and elevations shown, over an even, well compacted subgrade to form a continuous void space under the entire extent of the slab or grade beam.

C. For structural slab applications, 1/8-inch thick masonite or plywood sheet shall be placed over the void form. Void forms shall be placed in the largest pieces practical and shall be secured in place.

D. Properly surround and void around the upper portion of all drilled piers at the intersection of the slab, grade beam, or pier cap using a premanufactured, non-field cut sealed void form with a curved, radial, vertical edge adjacent to the drilled pier.

E. Void forms shall remain dry and undamaged prior to concrete placement. Damaged pieces shall be replaced prior to concrete placement. All joints and exposed ends shall be sealed to prevent leakage of concrete into the void space.

3.7 FIELD QUALITY CONTROL

A. Before concrete placement, check the formwork, including tolerances, lines, ties, tie cones, and form coatings. Make corrections and adjustments to ensure proper size and location of concrete members and stability of forming systems.

B. During concrete placement, check formwork and related supports to ensure that forms are not displaced and that completed Work shall be within specified tolerances.

C. If CONTRACTOR finds that forms are unsatisfactory in any way, either before or during placing of concrete, placement of concrete shall be postponed or stopped until the defects have been corrected, and reviewed by ENGINEER.

3.8 REMOVAL OF FORMS

A. Conform to the requirements of ACI 301, Section 2 and ACI 347, Chapter 3.7, except as specified below.

		Temperature (F)				
		Over 95°F	70°F-95°F	60°F-70°F	50°F-60°F	Below 50°F
a.	Walls	1 day	1 day	2 days	3 days	Do not remove
b.	Columns	2 days	1 day	3 days	4 days	forms until site-
c.	Beam Soffits	7 days	4 days	5 days	6 days	cured test cylinder

d.	Slabs 5 in. thick or less	7 days	5 days	6 days	7 days	develops 75% of 28-day strength.
e.	Slabs over 5 in. thick	7 days	6 days	7 days	7 days	

1. Removal of Forms and Supports: Continue curing in accordance with Section 03300, Cast-In-Place Concrete.

B. When high-early strength concrete is specified, a schedule for removal of forms will be developed in the field from the age/strength relationships established for the materials and proportions used by tests in accordance with ACI 301.

C. Form facing material shall remain in place a minimum of four days after concrete placement, unless otherwise approved by ENGINEER.

D. Results of suitable control tests of field-cured specimens may be used as evidence that the concrete has attained sufficient strength and that supporting forms and shoring may be removed prior to the periods indicated herein.

E. The time for removal of all forms will be subject to ENGINEER'S approval.

3.9 PERMANENT SHORES

A. Provide permanent shores as defined in ACI 347.

B. Reshores shall not be permitted.

3.10 RE-USE OF FORMS

A. Clean and repair surfaces of forms to be re-used in the Work. Split, frayed, delaminated or otherwise damaged form facing material will not be acceptable. Apply new form coating compound material to concrete contact surfaces as specified for new formwork.

B. When forms are extended for successive concrete placement, thoroughly clean surfaces, remove fins and laitance, and tighten forms to close all joints. Align and secure joints to avoid offsets. Do not use "patched" forms for exposed concrete surfaces. Form surfaces shall be subject to ENGINEER'S approval.

+ + END OF SECTION + +

SECTION 03200

CONCRETE REINFORCEMENT

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals as shown, specified and required to furnish and install concrete reinforcement.
   2. The extent of concrete reinforcement is shown.
   3. The Work includes fabrication and placement of reinforcement including bars, ties and supports, and welded wire fabric for concrete, encasements and fireproofing.

1.2 QUALITY ASSURANCE

A. Reference Standards: Comply with applicable provisions and recommendations of the following, except as otherwise shown or specified:
   1. ASTM A82, Specification for Steel Wire, Plain, for Concrete Reinforcement.
   2. ASTM A184, Specification for Fabricated Deformed Steel Bar Mats for Concrete Reinforcement.
   3. ASTM A185, Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement.
   4. ASTM A496, Specification for Steel Wire, Deformed, for Concrete Reinforcement.
   5. ASTM A497, Specification for Steel Welded Wire Fabric, Deformed, for Concrete Reinforcement.
   6. ASTM A615, Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
   7. ASTM A706, Specification for Low-Alloy Steel Deformed Bars for Concrete Reinforcement.
   8. ASTM A775, Specification for Epoxy-Coated Reinforcing Steel Bars.
   9. ACI 315, Manual of Standard Practice for Detailing Reinforced Concrete Structures.
   10. ACI 318, Building Code Requirements for Structural Concrete.
   11. ACI SP66, Detailing Manual.
   12. ANSI/AWS D1.4, Structural Welding Code - Reinforcing Steel.
   13. CRSI 1MSP, Concrete Reinforcing Steel Institute (CRSI) Manual of Standard Practice.

B. Allowable Placing Tolerances: Comply with ACI 318, Chapter 7 - Details of Reinforcement except as specified below:
   1. Concrete surfaces which are in contact with liquids: 2-inches minimum coverage.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Manufacturer's specifications and installation instructions for all materials and reinforcement accessories. Comply with the requirements of Section 01332, Shop Drawing Procedures.
   2. Drawings for fabrication, bending, and placement of concrete reinforcement. Comply with ACI 315, Parts A and B. For walls, show elevations to a minimum scale of 1/4-inch to one foot. For slabs, show top and bottom reinforcing on separate plan views. Show bar schedules, stirrup spacing, diagrams of bent bars, arrangements and assemblies, as required for the fabrication and placement of concrete reinforcement unless otherwise noted. Splices shall be kept to a minimum. Splices in regions of maximum tension stresses shall be avoided whenever possible.
   3. Drawings detailing the location of all construction and expansion joints as required under Section 03251, Concrete Joints, shall be submitted and approved before Shop Drawings for reinforcing steel are submitted.
   4. Description of reinforcing weld locations and weld procedures.

B. Certificates:
   1. Submit one copy of steel producer's certificates of mill analysis, tensile and bend tests for reinforcing steel.
   2. Submit certification of welders and weld procedures for splices in accordance with ANSI/AWS D1.4 requirements.

1.4 DELIVERY, HANDLING AND STORAGE

A. Deliver concrete reinforcement materials to the site bundled, tagged and marked. Use metal tags indicating bar size, lengths, and other information corresponding to markings shown on placement diagrams. Comply with the requirements of Section 01651, Transportation and Handling of Materials and Equipment.

B. Store concrete reinforcement material at the site to prevent damage and accumulation of dirt or excessive rust. Store on heavy wood blocking so that no part of it will come in contact with the ground. Comply with the requirements of 01661, Storage of Materials and Equipment.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Reinforcing Bars: ASTM A 615, and as follows:
   1. Provide Grade 60 for all bars, unless indicated otherwise.

2. At beams and columns forming frames and wall boundary elements, where indicated on the Drawings, provide ASTM A 706 or ASTM A 615, Grade 60, with a maximum yield stress of 78,000 psi.

B. Mechanical Couplers: Reinforcement bars may be spliced with a mechanical connection. This connection shall be a full mechanical connection which shall develop in tension or compression, as required, at least 125 percent of specified yield strength (fy) of the bar in accordance with ACI 318.

C. Steel Wire: ASTM A 82.

D. Welded Smooth Wire Fabric: ASTM A 185.
1. Furnish in flat sheets, not rolls.

E. Supports for Reinforcement: Bolsters, chairs, spacers and other devices for spacing, supporting and fastening reinforcement in place.
1. Use wire bar type supports complying with CRSI "Manual of Standard Practice" recommendations, except as specified below. Do not use wood, brick, or other unacceptable materials.
2. For slabs on grade, use precast concrete blocks, 4-inch square in plan, with embedded tie wire as specified by CRSI, "Manual of Standard Practice". The precast concrete blocks shall have the same or higher compressive strength as specified for the concrete in which they are located.
3. For all concrete surfaces, where legs of supports are in contact with forms, provide supports complying with CRSI "Manual of Standard Practice" as follows:
   a. At formed surfaces in contact with soil, weather, or liquid or located above liquid, supports shall be CRSI Class 1 for maximum protection. The plastic coating on the legs shall extend at least 1/2-inch upward from the form surface.
   b. At interior dry surfaces (not located above liquid), supports shall be either Class 1 or Class 2 for moderate protection.
   c. At formed surfaces with an architectural finish, use stainless steel protected legs (Type B).
4. Over waterproof membranes, use precast concrete chairs.

F. Drilled Dowels
1. Adhesive material for drilled dowels shall be a vinylester resin, epoxy resin, urethane methacrylate, or vinyl urethane resin. Polyester resin shall not be used. The resin shall be a high modulus, moisture insensitive type. The resin shall be packaged in a cartridge type dispensing system with a mixing nozzle. The resin shall be formulated to maintain its bond and integrity under continuous submergence by water. The adhesive anchoring systems shall have an ultimate capacity in excess of 125 percent of the yield strength of the reinforcing steel at an embedment of 12 bar diameters.
2. Adhesive systems shall be:

a. Hilti, Inc., Tulsa, OK; HIT-RE 500 V3 (ESR-3814) or HIT-HY 200 (ESR-3963) Adhesive.
b. Powers Fasteners, Brewster, NY; PURE110+ Epoxy (ESR-3298).
c. Simpson Strong-Tie Co., Inc., Pleasanton, CA; SET-XP Epoxy Adhesive (ESR-2508 for concrete) or (IAMPO UES ER-265 for masonry).
d. Or equal.

2.2 FABRICATION

A. General: Fabricate reinforcing bars to conform to required shapes and dimensions, with fabrication tolerances complying with CRSI, "Manual of Standard Practice". In case of fabricating errors, do not re-bend or straighten reinforcement in a manner that will injure or weaken the material.

B. Unacceptable Materials: Reinforcement with any of the following defects will not be permitted in the Work:
1. Bar lengths, bends, and other dimensions exceeding specified fabrication tolerances.
2. Bends or kinks not shown on approved Shop Drawings.
3. Bars with reduced cross-section due to excessive rusting or other cause.

PART 3 - EXECUTION

3.1 INSPECTION

A. Examine the substrate and the conditions under which concrete reinforcement is to be placed, and notify ENGINEER, in writing, of unsatisfactory conditions. Do not proceed with the Work until unsatisfactory conditions have been corrected in a manner acceptable to ENGINEER.

3.2 INSTALLATION

A. Comply with the applicable recommendations of specified codes and standards, and CRSI, "Manual of Standard Practice", for details and methods of reinforcement placement and supports.
B. Clean reinforcement to remove loose rust and mill scale, earth, ice, and other materials which reduce or destroy bond with concrete.

C. Position, support, and secure reinforcement against displacement during formwork construction or concrete placement operations. Locate and support reinforcing by metal chairs, runners, bolsters, spacers and hangers, as required.
1. Place reinforcement to obtain the minimum concrete coverages as shown and as specified in ACI 318. Arrange, space, and securely tie bars and bar supports together with 16 gage wire to hold reinforcement accurately in position during

concrete placement operations. Set wire ties so that twisted ends are directed away from exposed concrete surfaces.

2. Prior to placement of concrete, demonstrate to ENGINEER that the specified cover of reinforcement has been attained, by using a surveying level or string line.
3. Reinforcing steel shall not be secured to forms with wire, nails or other ferrous metal. Metal supports subject to corrosion shall not touch formed or exposed concrete surfaces.

D. Install welded wire fabric in as long lengths as practical. Lap adjoining pieces at least one full mesh and lace splices with 16-gage wire. Do not make end laps midway between supporting beams, or directly over beams of continuous structures. Offset end laps in adjacent widths to prevent continuous laps.

E. Provide sufficient numbers of supports of strength required to carry reinforcement. Do not place reinforcing bars more than 2-inches beyond the last leg of any continuous bar support. Do not use supports as bases for runways for concrete conveying equipment and similar construction loads.

F. Lap Splices:
1. Provide standard reinforcement splices by lapping ends, placing bars in contact, and tying tightly with wire. Comply with requirements shown for minimum lap of spliced bars, in accordance with the requirements of ACI.

G. Mechanical Couplers:
1. Mechanical butt splices shall be in accordance with the recommendation of the manufacturer of the mechanical splicing device. Butt splices shall develop 125 percent of the specified minimum yield tensile strength of the spliced bars or of the smaller bar in transition splices. Bars shall be flame dried before butt splicing. Adequate jigs and clamps or other devices shall be provided to support, align, and hold the longitudinal centerline of the bars to be butt spliced in a straight line.

H. Welded Splices
1. When permitted by the ENGINEER, in writing, all welding of reinforcing bars shall conform to ANSI/AWS D1.4. Preheating and rate of cooling requirements shall be based on bar steel chemistry and ANSI/AWS D1.4 requirements. Welded splices shall be sized and constructed to transfer a minimum of 125 percent of the specified minimum yield tensile strength of the spliced bars or of the smaller bar in transition splices. Unless otherwise permitted by the Engineer, welding of crossing bars (tack welding) for assembly of reinforcement is prohibited.
2. Welding of wire to wire, and of wire or welded wire fabric to reinforcing bars or structural steels, shall conform to applicable provisions of ANSI/AWS D1.4 and any supplementary requirements by the ENGINEER for the particular application.

3. After completion of welding on coated reinforcing bars, coating damage shall be repaired as specified herein. All welds and all steel splice members when used to splice bars shall be coated with the same material used for repair of coating damage.

I. Drilled Dowels
1. Drilled dowels shall be reinforcing dowels set in a resin adhesive in a hole drilled into hardened concrete.
2. Holes shall be drilled to the adhesive anchor system manufacturer's recommended diameter and depth to develop the required pullout resistance but shall not be greater in diameter than 1/4-inch more than the nominal bar diameter nor less than 12 times the nominal bar diameter in depth.
3. The hole shall be drilled by methods which do not interfere with the proper bonding of the resin. Only masonry type drill bits shall be used.
4. Existing reinforcing steel in the vicinity of proposed holes shall be located prior to drilling. The location of holes to be drilled shall be adjusted to avoid drilling through or nicking any existing reinforcing bars only after approval by the ENGINEER.
5. The hole shall be brushed (non-metallic bristle brush only) and blown clean with clean, dry compressed air to remove all dust and loose particles.
6. Resin shall be injected into the hole through the injection system-mixing nozzle (and any necessary extension tubes) placed to the bottom of the hole. The discharge end shall be withdrawn as resin is placed but kept immersed to prevent formation of air pockets. The hole shall be filled to a depth that ensures that excess material is expelled from the hole during dowel placement.
7. Dowels shall be twisted during insertion into the partially filled hole so as to guarantee full wetting of the bar surface with resin. The bar shall be inserted slowly enough to avoid developing air pockets.

3.3 INSPECTION OF REINFORCEMENT

A. Concrete shall not be placed until the reinforcing steel is inspected and permission for placing concrete is granted by ENGINEER. All concrete placed in violation of this provision will be rejected.

B. Formwork for walls and other vertical members will not be closed up until the reinforcing steel is inspected and permission for placing concrete is granted by ENGINEER. All concrete placed in violation of this provision will be rejected.

C. Testing of Drilled Dowels: Employ a testing agency to perform field quality control testing of the drilled dowel installation. After completion of the manufacturer's recommended curing period and prior to placement of connecting reinforcing, ten percent of drilled dowels installed shall be proof tested for pullout. The drilled dowels shall be tensioned to 60 percent of the specified yield strength. Where dowels are located less than six bar diameters from the edge of concrete, the ENGINEER will determine the tensile load required for the test. If any dowels fail,

all installed dowels shall be tested. Dowels that fail shall be reinstalled and retested at CONTRACTOR'S expense.

D. Inspection of Welded Splices: Employ a testing agency to perform field quality control testing of the welded splices. All welded splices shall be visually inspected. A minimum of five percent of butt splice welds shall be radiographically tested. Any weld which is deficient in any way shall be repaired to be completely sound at the CONTRACTOR'S expense.

+ + END OF SECTION + +

SECTION 03251

CONCRETE JOINTS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals as shown, specified and required to furnish and install concrete joints.
   2. The types of concrete joints required include the following:
      a. Construction joints.
      b. Expansion joints.
      c. Control joints.
      d. Isolation joints.
      e. Waterstops.

B. General: All joints subject to hydrostatic pressure or in contact with soil, except non-water bearing slabs-on-grade, shall be provided with continuous waterstop.

1.2 QUALITY ASSURANCE

A. Standard Specifications Details:
   1. Conform all applicable requirements of Sections No. 505 and 729 of the Uniform Standard Specifications for Public Works Construction by the Maricopa Association of Governments (MAG) as supplemented by the City of Phoenix. Where there is a conflict between MAG Standard Specifications as supplemented by the City of Phoenix and this Specification, provisions of this Specification shall govern.

B. Reference Standards: Comply with applicable provisions and recommendations of the following, except as otherwise shown or specified:
   1. ACI 301, Standard Specifications for Structural Concrete.
   2. ASTM C 920, Standard Specification for Elastomeric Joint Sealants.
   3. ASTM D 412, Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers-Tension.
   4. ASTM D 624, Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers.
   5. ASTM D 1752, Standard Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction.
   6. ASTM D 2240, Test Method for Rubber Property – Durometer Hardness.
   7. CRD-C572, U.S. Army Corps of Engineers Specifications for Polyvinyl-Chloride Waterstop.

C. All manufactured items shall be installed in accordance with manufacturer's instructions.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Manufacturer's specifications and installation instructions for all materials required.
   2. Layout of all construction and expansion joint locations prior to the submittal of steel reinforcement Shop Drawings. Comply with the requirements of Section 01332, Shop Drawing Procedures.

B. Samples: Submit for approval the following:
   1. Polyvinyl chloride waterstops for joints for each cross section type used.
   2. Foam rubber and cork expansion joint fillers.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING

A. All materials used for joints in concrete shall be stored on platforms or in enclosures and covered to prevent contact with the ground and exposure to the weather and direct sunlight. Storage and handling requirements of the manufacturer shall also be followed.

PART 2 - PRODUCTS

2.1 WATERSTOPS

A. Polyvinyl Chloride:
   1. Material Requirements:
      a. Waterstops shall be extruded from an elastomeric polyvinyl chloride compound containing the plasticizers, resins, stabilizers, and other materials necessary to meet the requirements of these Specifications and the requirements of CRD-C572. No reclaimed or scrap material shall be used.
      b. Tensile strength of finished waterstop: 1400 psi, minimum.
      c. Ultimate elongation of finished waterstop: 280 percent, minimum.
      d. Minimum thickness shall be 3/8-inch.
      e. Waterstops shall be provided with a minimum of seven ribs equally spaced at each end on each side. The first rib shall be at the edge. Ribs shall be a minimum of 1/8-inch in height.
   2. Construction Joints: Waterstops shall be flatstrip ribbed type and 6-inches minimum in width, unless shown otherwise.
   3. Expansion Joints: Waterstops shall be centerbulb ribbed type and 9-inches minimum in width, unless shown otherwise. The centerbulb shall have a minimum outside diameter of 7/8-inch.
   4. Product and Manufacturer: Provide one of the following:
      a. W.R. Meadows, Incorporated.

b. A.C. Horn, Incorporated.
c. Sika-Greenstreak Plastic Products Company
d. Water Seals, Inc.
e. Paul Murphy Plastics Company.
f. Or equal.

2.2 HYDROPHILIC WATERSTOP MATERIALS

A. General Material Properties
1. Hydrophilic waterstop materials shall be bentonite-free and shall expand by a minimum of 80 percent of dry volume in the presence of water to form a watertight joint seal without damaging the concrete in which it is cast. Provide only where indicated in the Contract Documents.
2. The material shall be composed of resins and polymers which absorb water and cause an increase in volume in a completely reversible and repeatable process. The waterstop material shall be dimensionally stable after repeated wet-dry cycles with no deterioration of swelling potential.
3. Select materials which are recommended by the manufacturer for the type of liquid to be contained.

B. Hydrophilic Rubber Waterstop
1. The minimum cross sectional dimensions shall be 3/16-inch by 3/4-inch.
2. Product and Manufacturer: Provide one of the following:
a. Duroseal Gasket, by BBZ USA, Inc.
b. Adeka Ultraseal MC-2010M, by Asahi Denka Kogyo K.K.
c. Or equal.

C. Hydrophilic Sealant:
1. The hydrophilic sealant shall adhere firmly to concrete, metal, and PVC in dry or damp condition. When cured it shall be elastic indefinitely.
2. Product and Manufacturer: Provide one of the following:
a. Duroseal Paste, by BBZ USA, Inc.
b. Adeka Ultraseal P-201, by Asahi Denka Kogyo K.K.
c. SikaSwell S, by Sika Corporation.
d. Or equal.

D. Hydrophilic Injection Resin
1. Hydrophilic injection resin shall be acrylate-ester based. The viscosity shall be less than 50 cps. The resin shall be water soluble in its uncured state, solvent free, and non-water reactive. In the cured state it shall form a solid hydrophilic flexible material which is resistant to permanent water pressure and shall not attack bitumen, joint sealants, or concrete.
2. Product and Manufacturer: Provide one of the following:
a. Duroseal Inject 1K/2K, by BBZ USA, Inc.
b. Sika Injection 29, by Sika Corporation.
c. Or equal.

2.3 PREFORMED EXPANSION JOINT FILLER

A. Provide preformed expansion joint filler complying with ASTM D 1752, Type I (sponge rubber) or Type II (cork).

2.4 CONCRETE CONSTRUCTION JOINT ROUGHENER

A. Provide a water-soluble non-flammable, surface-retardant roughener.

B. Product and Manufacturer: Provide one of the following:
   1. Rugasol-S, as manufactured by Sika Corporation for horizontal joints only.
   2. Concrete Surface Retarder-Formula S, as manufactured by Euclid Chemical Company, for horizontal joints only.
   3. Concrete Surface Retarder-Formula F, as manufactured by Euclid Chemical Company, for vertical joints only.
   4. Or equal.

2.5 EPOXY BONDING AGENT

A. Provide a two-component epoxy-resin bonding agent.

B. Product and Manufacturer: Provide one of the following:
   1. Sikadur 32 Hi-Mod LPL, as manufactured by Sika Corporation.
   2. Eucopoxy LPL, as manufactured by the Euclid Chemical Company.
   3. Or equal.

2.6 EPOXY-CEMENT BONDING AGENT

A. Provide a three component epoxy resin-cement blended formulated as a bonding agent.

B. Product and Manufacturer: Provide one of the following:
   1. Sika Armatec 110 EpoCem, as manufactured by Sika Corporation.
   2. Corr-Bond, as manufactured by the Euclid Chemical Company.
   3. Or equal.

2.7 RUBBER BONDING AGENT

A. Product and Manufacturer: Provide one of the following:
   1. Scotch-Grip 1300 Rubber Adhesive, as manufactured by 3M Company.
   2. Or equal.

2.8 NEOPRENE BEARING PADS

A. Product and Manufacturer: Provide one of the following:

1. 65 Durometer, Sheet Neoprene No. 1200, as manufactured by Williams Products Company.
2. Or equal.

2.9 JOINT SEALANT

A. Sealant used in expansion joints and other locations where it is shown and which will be subject to being submerged by water for any period of time shall be a two part polyurethane type sealant meeting the requirements of ASTM C 920, Type M, Class 25. The sealant shall be specially formulated for continuous submerged conditions. The manufacturer's recommended primer must be used with the sealant.

B. The sealant shall meet the following requirements (measured at 73 degrees F and 50 percent RH):
   1. Ultimate hardness (ASTM D 2240, Type A, Shore): 20 to 45.
   2. Tensile strength (ASTM D 412): 200 psi, minimum.
   3. Ultimate elongation (ASTM D 412): 400 percent, minimum.
   4. Tear strength (ASTM D 624, die C): 75 pounds per inch of thickness, minimum.
   5. Color: light gray.

C. Product and Manufacturer: Provide one of the following:
   1. Permapol RC-270 Reservoir Sealant, as manufactured by Products Research and Chemical Corporation.
   2. Sikaflex-2c, as manufactured by Sika Corporation.
   3. Or equal.

2.10 SEALANT ACCESSORIES

A. Backer Rod: Backer rod shall be an extruded closed-cell polyethylene foam rod. The material shall be compatible with the sealant material used and shall have a tensile strength of not less than 40 psi and a compression deflection of approximately 25 percent at 8 psi. The rod shall be 1/8-inch larger in diameter than the joint width at joints less than 3/4-inch wide and 1/4-inch larger in diameter at joints 3/4-inch and wider.

B. Bond Breaker Tape: Bond breaker shall be polyethylene or TFE-fluorocarbon self adhesive tape, as recommended by the manufacturer.

PART 3 - EXECUTION

3.1 INSPECTION

A. Examine the substrate and the conditions under which Work is to be performed and notify ENGINEER, in writing, of unsatisfactory conditions. Do not proceed with the Work until unsatisfactory conditions have been corrected in a manner acceptable to ENGINEER.

3.2 CONSTRUCTION JOINTS

A. Comply with the requirements of ACI 301 and as specified below.

B. Locate and install construction joints as shown on the Drawings. Additional construction joints shall be located as follows:
   1. In walls locate joints at a spacing of 40 feet maximum and approximately 12 feet from corners.
   2. In foundation slabs and slabs on grade locate joints at a spacing of approximately 40 feet. Place concrete in a strip pattern, unless otherwise indicated on the Drawings.
   3. In mats and structural slabs and beams, at a spacing of approximately 40 feet. Locate joints in compliance with ACI 301, unless otherwise indicated on the Drawings.
   4. Provide other additional construction joints as required to satisfactorily complete all Work.

C. Horizontal Joints:
   1. Roughen concrete at the interface of construction joints by abrasive blasting, hydroblasting, or the use of surface retardants and water jets to expose the aggregate and remove accumulated concrete on projecting rebar immediately subsequent to form stripping, unless otherwise approved by ENGINEER. Immediately before placing fresh concrete, thoroughly clean the existing contact surface using a stiff brush or other tools and a stream of water under pressure. The surface shall be clean and wet, but free from pools of water at the moment the fresh concrete is placed.
   2. Remove laitance, waste mortar or any other substance which may prevent complete adhesion. Where joint roughening was performed more than seven days prior to concrete placement or where dirt or other bond reducing contaminants are on the surface, additional light abrasive blasting or hydroblasting shall be done to remove laitance and all bond reducing materials just prior to concrete placement.
   3. Place a 2-inch thick coat of mortar, one part sand and one part cement with water added to a flowable consistency or a 6-inch layer of Construction Joint Grout, as specified in Section 03600, Grout, over the contact surface of the old concrete. Place fresh concrete before the mortar or grout has attained its initial set. If the concrete mix has the slump increased to at least 6-inches by addition of a high range water reducer, the placement of mortar or grout may be omitted.

D. Vertical Joints:
   1. Apply roughener to the form in a thin, even film by brush, spray or roller in accordance with the manufacturer's instructions. After roughener is dry, concrete may be placed.
   2. When concrete has been placed, remove joint surface forms as early as is necessary to allow for removal of the surface retarded concrete. Forms covering member surfaces shall remain in place as required by Section 03100, Concrete Formwork. Wash loosened material off with high-pressure water spray to obtain roughened surface subject to approval by ENGINEER. Alternately, the surface shall be roughened by abrasive blasting or hydroblasting to expose aggregate. The outer 1-inch of each side of the joint face shall be masked and protected from the blasting to avoid damage to the member surface.

3.3 EXPANSION JOINTS

A. Comply with the requirements of ACI 301 and as specified below.

B. Locate and install expansion joints as shown. Install joint filler in accordance with manufacturer's instructions. Sealants shall be installed as specified herein.

3.4 CONTROL JOINTS

A. Control joints shall be provided in non-water bearing slabs on grade only where specifically shown. A groove, with a depth of at least 25 percent of the member thickness, shall be formed or saw-cut in the concrete. This groove shall be filled with joint sealant material as specified in Section 07920, Caulking and Sealants.

B. Where the control joint is formed by sawcutting, the cut shall be made immediately after the concrete has set enough to support the saw and be cut without being damaged. The concrete shall be kept continually moist until the cutting operation.

C. Control joints may be formed with a tool or by insertion of a joint forming strip. After the concrete has gained its design strength, the upper portion of the joint forming strip shall be removed and the void filled with sealant.

3.5 ISOLATION JOINTS

A. Wherever a sidewalk or other slab on grade abuts a concrete structure and is not shown doweled into that structure, an isolation joint shall be provided. Such joint shall be formed by a 1/2-inch joint filler with the upper 1/2-inch of the joint filled with sealant.

3.6 WATERSTOPS

A. General:

1. Comply with the requirements of ACI 301 and as specified below. All joints shall be made in accordance with manufacturer's instructions.
2. Obtain ENGINEER'S approval for waterstop locations not shown.
3. Provide polyvinyl chloride waterstops in all joints in concrete which are intended to retain liquid or are located below grade up to an elevation at least 12-inches above grade or to an elevation at least 12-inches above overflow liquid level in tanks, whichever is higher, except where otherwise shown or noted.

B. Polyvinyl Chloride Waterstop:
   1. Tie waterstop to reinforcement, at a maximum spacing of 18-inches, so that it is securely and rigidly supported in the proper position during concrete placement. Continuously inspect waterstops during concrete placement to ensure their proper positioning.
   2. Splices in waterstops shall be performed by heat sealing the adjacent waterstop sections in accordance with the manufacturer's printed recommendations. It is required that:
      a. The material shall not be damaged by heat sealing.
      b. The splices shall have a tensile strength of not less than 60 percent of the unspliced materials tensile strength.
      c. The continuity of the waterstop ribs and of its tubular center axis shall be maintained.
   3. Only butt type joints of the ends of two identical waterstop sections shall be allowed to be made while the material is in the forms.
   4. All joints with waterstops involving more than two ends to be jointed together, and all joints which involve an angle cut, alignment change, or the joining of two dissimilar waterstop sections shall be prefabricated by CONTRACTOR or manufacturer prior to placement in the forms, allowing not less than 24-inch long strips of waterstop material beyond the joint. Upon being inspected and approved, such prefabricated waterstop joint assemblies shall be installed 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. Where a centerbulb waterstop intersects and is jointed with a non-centerbulb waterstop, care shall be taken to seal the end of the centerbulb, using additional PVC material, if required.
   6. The symmetrical halves of the waterstops shall be equally divided between the concrete placements at the joints and centered within the joint width, unless shown otherwise. Centerbulb waterstops shall be placed in expansion joints so that the centerbulb is centered on the joint filler material.
   7. When any waterstop is installed in the forms or is embedded in the first concrete placement and the waterstop remains exposed to the atmosphere for more than four days, suitable precautions shall be taken to shade and protect the exposed waterstop from direct rays of the sun during the entire exposure and until the exposed portion of the waterstop is embedded in concrete.
   8. Waterstop placed in joints intended for future concrete placement shall be protected from direct rays of the sun by temporary means until a permanent

cover is installed so that the waterstop is not exposed to the direct rays of the sun for more than a total of four days.

C. Hydrophilic Rubber Waterstop and Sealant
   1. Where a hydrophilic rubber waterstop or sealant is called for in the Contract Documents, or where approved by the ENGINEER, it shall be installed with the manufacturer's instructions and recommendations; except, as modified herein.
   2. When requested by the ENGINEER, the manufacturer shall provide technical assistance in the field.
   3. The waterstop or sealant shall be located as near as possible to the center of the joint and it shall be continuous around the entire joint. The minimum distance from the edge of the waterstop to the face of the member shall be 3-inches.
   4. Where a hydrophilic rubber waterstop is used in combination with PVC waterstop, the hydrophilic rubber waterstop shall overlap the PVC waterstop for a minimum of 6-inches. The contact surface between the hydrophilic rubber waterstop the PVC waterstop shall be filled with hydrophilic sealant.
   5. Where wet curing methods are used, hydrophilic rubber waterstop and sealant shall be applied after curing water is removed and just prior to the closing up of the forms for the concrete placement. Hydrophilic rubber waterstop and sealant shall be protected from the direct rays of the sun and from becoming wet prior to concrete placement. If the material does become wet and expands, it shall be allowed to dry until it has returned to its original cross sectional dimensions before concrete is placed.
   6. The hydrophilic rubber waterstop shall be installed in a bed of hydrophilic sealant, before skinning and curing begins, so that any irregularities in the concrete surface are completely filled and the waterstop is bonded to the sealant. After the sealant has cured, concrete nails, with washers of a diameter equal to the waterstop width, shall be placed to secure the waterstop to the concrete at a maximum spacing of 18-inches.
   7. Prior to installation of hydrophilic sealant, the concrete surface shall be wire brushed or sand blasted to remove any laitance or other materials that may interfere with the bonding. Surfaces of metal or PVC to receive sealant shall be cleaned of paint and any material that may interfere with bond. When sealant alone is shown on the Contract Documents, it shall be placed in a built up bead which has a triangular cross section with each side of the triangle at least 3/4-inch in length, unless indicated otherwise. Concrete shall not be placed until the sealant has cured as recommended by the manufacturer.

3.7 BONDING AGENT

A. Use epoxy bonding agent for bonding of fresh concrete to concrete that has been in place for at least 60 days or to existing concrete.

B. Use epoxy-cement bonding agent for the following:
   1. Bonding toppings and concrete fill to concrete that has been in place for at least 60 days or to existing concrete.

2. For all locations where bonding agent is required and concrete cannot be placed within the open time period of epoxy bonding agent.
3. Bonding of horizontal construction joints where these are required by the Drawings or approved by ENGINEER for foundation mats that are five feet thick or greater.

C. Use a cement-water slurry as a bonding agent for toppings and concrete fill to new concrete. The cement water slurry shall be worked into the surface with a stiff bristle broom and concrete shall be placed before the cement-water slurry dries.

D. Handle and store bonding agent in compliance with the manufacturer's printed instructions, including safety precautions.

E. Mix the bonding agent in complete accordance with the instructions of the manufacturer.

F. Before placing fresh concrete, thoroughly roughen and clean hardened concrete surfaces and coat with bonding agent not less than 1/16-inch thick. Place fresh concrete while the bonding agent is still tacky (within its open time), without removing the in-place bonding agent coat, and as directed by the manufacturer.

3.8 SEALANT INSTALLATION

A. Sealants shall be installed according to the manufacturer's recommendations for sealant which is to be subjected to continuous submerged conditions and the following requirements. Prior to sealant installation, arrange to have a representative of the sealant manufacturer instruct the crew doing the Work as to the proper methods of surface preparation, mixing, and application of the sealant.

B. Surfaces to receive sealant shall be cleaned of all materials which could interfere with proper bonding. Concrete surfaces shall have all fins or other defects removed or repaired and shall receive a light abrasive blasting prior to priming and sealant application. All surfaces to receive sealant shall be completely dry.

C. Spaces to receive sealant shall be filled with joint filler as shown. Where not shown, the space shall be filled with joint filler or a backer rod so that the depth of sealant does not exceed the width of the space. Where the bottom of the space to receive sealant is formed by a material other than backer rod, a bond breaker tape shall be placed. The maximum sealant depth, at middle of the joint width, shall be 1/2-inch.

D. The primer and sealant used shall be supplied by the same manufacturer. No sealant shall be placed without the use of a primer.

E. Self-leveling sealants shall only be used in joints with a slope less than 0.5 percent and where maximum and minimum sealant depths can be maintained. Non-sag sealant shall be used at all other locations and may be used instead of self-leveling

sealant. All non-sag sealant shall be tooled to a uniform concave surface before skinning and curing begins.

F. Sealant material shall be conditioned to be within the optimum temperature range recommended by the manufacturer for installation for a minimum of 16 hours prior to installation. Installation shall proceed only when the substrate is at a temperature recommended by the manufacturer. Sealant shall not be placed if there is a threat of imminent rainfall. Submit a letter certifying that the applied sealants were installed in accordance with the manufacturer's recommendations, including temperature, relative humidity, etc.

G. All joints to receive sealant shall be inspected by the ENGINEER prior to sealant placement.

H. All sealant shall achieve final cure at least seven days before the structure is filled with water.

I. Any sealant which, after the manufacturer's recommended curing time for the job conditions, fails to fully and properly cure shall be completely removed. The surfaces to receive sealant shall be completely cleaned of all traces of the improperly cured sealant and primer. The specified sealant shall then be reinstalled. All costs of such removal, surface treatment, and reinstallation shall be at the expense of CONTRACTOR.

3.9 BEARING PAD INSTALLATION

A. Neoprene Bearing Pad: Install with water insensitive adhesive in accordance with manufacturer's instructions.

+ + END OF SECTION + +

SECTION 03252

ANCHORAGE IN CONCRETE

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals as shown on the Drawings, specified, and required to furnish and install anchor bolts, concrete anchors (adhesive and expansion anchors), and concrete inserts.

B. Coordination: This Section includes all bolts, anchors and inserts required for the Work but not specified under other Sections.

C. The types of work using anchor bolts and anchors drilled into concrete or masonry includes, but is not limited to, the following:
   1. Structural members and accessories.
   2. Metal, wood, and plastic fabrications.
   3. Equipment.
   4. Piping.
   5. Grating and floor plate.
   6. Electrical, Plumbing and HVAC Work.

1.2 QUALITY ASSURANCE

A. Reference Standards: Comply with the applicable provisions and recommendations of the following, except as otherwise shown and specified.
   1. ASTM A36, Specification for Structural Steel.
   2. ASTM A123, Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   3. ASTM A153, Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   4. ASTM A307, Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
   5. ASTM A484/A 484M, Specification for General Requirements for Stainless and Heat-Resisting Steel Bars, Billets and Forgings.
   6. ASTM A525, Specification for General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process.
   7. ASTM A536, Specification for Ductile Iron Castings.
   8. ASTM A570/A 570M, Specification for Structural Steel, Sheet and Strip, Carbon, Hot-Rolled.
   9. ASTM B633, Specification for Electrodeposited Coatings of Zinc on Iron and Steel.

10. ASTM F593, Specification for Stainless Steel Bolts; Hex Cap Screws, and Studs.
11. Federal Specification, FF-S-325 for Concrete Expansion Anchors.
12. Federal Specifications, WW-H-171E for Malleable Iron.

B. Expansion anchors and inserts shall be ICBO, UL, or FM approved.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
1. Setting drawings and templates for location and installation of anchorage devices.
2. Copies of manufacturer's specifications, load tables, dimension diagrams and installation instructions for the anchorage devices.
3. Copies of ICBO, UL, or FM reports certifying load carrying capacities and installation requirements for the anchorage devices.

B. Samples: Submit for approval the following:
1. Representative samples of bolts, anchors and inserts as may be requested by ENGINEER. Review will be for type and finish only. Compliance with all other requirements is exclusive responsibility of CONTRACTOR.

PART 2 - PRODUCTS

2.1 DESIGN CRITERIA

A. When the size, length or load carrying capacity of an anchor bolt, concrete anchor, or concrete insert is not shown on the Drawings, provide the following:
1. For anchor bolts (cast-in-place), provide the size, length and capacity required to carry the design load based on the values and requirements given in the Phoenix Building Code.
2. For concrete anchors (adhesive types) and concrete inserts, provide the size, length, type, and capacity required to carry the design load based on the values and requirements given in the ICBO Evaluation Report, or similar certifications by UL or FM, for the anchor to be used. Alternately the capacity may be based on independent testing lab capacities for tension and shear strength using a minimum safety factor of four. Consideration of reduced capacity due to spacing and edge distance shall be made.

B. Determine design loads as follows:
1. For equipment anchors, use the design load recommended by the equipment manufacturer and approved by ENGINEER.
2. For pipe hangers and supports, use one half of the total weight of: pipe, fittings, and water contained in pipe, plus the full weight of valves and accessories located between the hanger or support in question.
3. Allowances for vibration are included in the safety factor specified above.

4. Concrete anchors shall develop ultimate shear and pull-out loads of not less than the following values in 4000 psi concrete:

Bolt diameter (Inches)	Min Shear (Pounds)	Min Pull-Out Load (Pounds)
1/2	5,000	7,600
5/8	8,000	12,000
3/4	11,500	17,000
7/8	15,700	20,400
1	20,500	28,400

2.2 APPLICATION

A. Where a concrete anchor is shown on the Drawings, either an adhesive anchor or anchor bolt shall be used. In masonry, where a concrete anchor is indicated, only anchor bolts and adhesive anchors shall be used.

B. Anchor Bolts (cast-in-place)
   1. Shall be used where indicated and may be used where concrete anchors are indicated.
   2. Where an anchor bolt is indicated, only a cast-in-place anchor bolt shall be used, unless another anchor type is accepted by the ENGINEER.
   3. Provide anchor bolts as shown on the Drawings or as required to secure structural steel to concrete or masonry.

C. Concrete Inserts:
   1. Use only where indicated.
   2. Use for pipe hangers and supports for the pipe size and loading recommended by the insert manufacturer.

2.2 MATERIALS

A. Anchor Bolts:
   1. Provide carbon steel bolts complying with ASTM A 307, headed or non-headed type, unless otherwise indicated.
   1. Provide stainless steel bolts complying with ASTM F 593, AISI Type 316 headed or non-headed type with nitronic 60 stainless steel nuts and locknuts, unless otherwise indicated.
   2. In buried or submerged locations, provide stainless steel bolts complete with washers complying with ASTM F 593, AISI Type 316 and with nitronic 60 stainless steel nuts and locknuts. Other AISI types may be used subject to ENGINEER'S approval.

3. For equipment, provide anchor bolts, which meet the equipment manufacturer's recommendations for size, material, and strength.
4. Provide anchor bolts as shown on the Drawings or as required to secure structural steel to concrete or masonry.
5. Locate and accurately set the anchor bolts using templates or other devices as required.
6. Protect threads and shank from damage during installation of equipment and structural steel.
7. Comply with manufacturer's required embedment length and necessary anchor bolt projection.

B. Concrete Inserts:
1. For piping, grating, floor plate and masonry lintels, provide malleable iron inserts. Comply with Federal Specification WW-H-171E (Type 18). Provide those recommended by the manufacturer for the required loading.
2. Finish shall be black.
3. Product and Manufacturer: Provide one of the following:
a. Figure 282, as manufactured by ITT Grinnell.
b. No. 380, as manufactured by Hohmann and Barnard, Incorporated.
c. Or equal.

C. Powder actuated fasteners and other types of bolts and fasteners not specified herein shall not be used unless approved by ENGINEER.

PART 3 - EXECUTION

3.1 INSPECTION

A. Examine areas and conditions under which anchor bolts, expansion anchors and concrete insert Work is to be installed, and notify ENGINEER, in writing, of conditions detrimental to proper and timely completion of Work. Do not proceed with Work until unsatisfactory conditions have been corrected in a manner acceptable to ENGINEER.

3.2 INSTALLATION

A. Assure that embedded items are protected from damage and are not filled in with concrete.

B. Use concrete inserts for pipe hangers and supports for the pipe size and loading recommended by the insert manufacturer.

3.3 CLEANING

A. After embedding concrete is placed, remove protection and clean bolts and inserts.

3.4 FIELD QUALITY CONTROL

A. Employ a testing laboratory to perform field quality testing of installed anchors. Field engineer is to determine the level of testing which is required for the various types of adhesive anchors and anchor bolts. A minimum of ten percent of the adhesive anchors and reinforcing bars are to be tested to 50 percent of the ultimate tensile capacity of the adhesive anchor or reinforcing bar.

B. If failure of any of the adhesive anchors or reinforcing bars occurs, testing the remaining 90 percent will be required and the costs involved belong to the CONTRACTOR. Responsibility belongs to CONTRACTOR to correct improper workmanship, remove and replace, or correct as directed by the ENGINEER, all adhesive anchors or bars found unacceptable or deficient, at no additional cost to the OWNER.

D. The independent testing and inspection agency shall complete a report on each area of the Work where concrete anchors are installed. The report shall summarize the observations made by the inspector and be submitted to ENGINEER.

E. Provide access for the testing agency to places where work is being produced so that required inspection and testing can be accomplished.

+ + END OF SECTION + +

SECTION 03300

CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals as shown, specified and required to furnish and install cast-in-place concrete.
   2. The Work includes providing concrete consisting of portland cement, fine and coarse aggregate, water, and approved admixtures; combined, mixed, transported, placed, finished and cured. The Work also includes:
      a. Providing openings in concrete to accommodate the Work under this and other Sections and building into the concrete all items such as sleeves, frames, anchor bolts, inserts and all other items to be embedded.

B. Coordination:
   1. Review installation procedures under other Sections and coordinate the installation of items that must be installed in the concrete.

C. Classifications of Concrete:
   1. Type "1" concrete shall be steel reinforced and includes the following:
      a. All concrete, unless indicated otherwise.
   2. Type "2" concrete shall be placed without forms or with simple forms, with little or no reinforcing, and includes the following:
      a. Concrete fill within structures.
      b. Duct banks.
      c. Unreinforced encasements.
      d. Curbs and gutters.
      e. Sidewalks.
      f. Thrust blocks.

1.2 QUALITY ASSURANCE

A. Standard Specifications and Details:
   1. Conform to all applicable requirements of Section Nos. 505, 725 and 726 of the Uniform Standard Specifications for Public Works Construction by the Maricopa Association of Governments (MAG) as supplemented by the City of Phoenix. Where there is a conflict between MAG Standard Specifications as supplemented by the City of Phoenix and this Specification, provisions of this Specification shall govern.

B. Reference Standards: Comply with the applicable provisions and recommendations of the following, except as otherwise shown or specified.

1. ACI 214, Recommended Practice for Evaluation of Strength Test Results of Concrete.
2. ACI 301, Specifications for Structural Concrete (includes ASTM Standards referred to herein).
3. ACI 304, Guide for Measuring, Mixing, Transporting and Placing Concrete.
4. ACI 305, Hot Weather Concreting.
5. ACI 306, Cold Weather Concreting.
6. ACI 309, Guide for Consolidation of Concrete.
7. ACI 311, Guide for Concrete Inspection.
8. ACI 318, Building Code Requirements for Structural Concrete.
9. ANSI/NSF 61, Drinking Water System Components-Health Effects.
10. AASHTO M 182, Burlap Cloth Made From Jute or Kenaf.
11. AASHTO TP 23, Proposed Standard Method of Test for Water Content of Freshly Mixed Concrete Using Microwave Oven Drying.
12. ASTM C 31, Practice for Making and Curing Concrete Test Specimens in the Field.
13. ASTM C 33, Specification for Concrete Aggregates.
14. ASTM C 39, Test Method for Compressive Strength of Cylindrical Concrete Specimens.
15. ASTM C 42, Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
16. ASTM C 94, Specification for Ready-Mixed Concrete.
17. ASTM C109, Test Method for Compressive Strength of Hydraulic Cement Mortars.
18. ASTM C 143, Test Method for Slump of Hydraulic- Cement Concrete.
19. ASTM C 150, Specification for Portland Cement.
20. ASTM C 157, Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete.
21. ASTM C 171, Specification for Sheet Materials for Curing Concrete.
22. ASTM C 172, Practice for Sampling Freshly Mixed Concrete.
23. ASTM C 231, Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
24. ASTM C 260, Specification for Air-Entraining Admixtures for Concrete.
25. ASTM C 309, Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
26. ASTM C 330, Specification for Lightweight Aggregates for Structural Concrete.
27. ASTM C 494, Specification for Chemical Admixtures for Concrete.
28. ASTM C 618, Specification for Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete.
29. ASTM C 882, Test Method for Bond Strength of Epoxy-Resin Systems Used with Concrete by Slant Shear.
30. ASTM C 1240, Specification for Silica Fume for Use as a Mineral Admixture in Hydraulic-Cement Concrete, Mortar, and Grout.
31. ASTM E 154, Test Methods for Water Vapor Retarders Used in Contact with Earth Under Concrete Slabs, on Walls, or as Ground Cover.

32. ASTM E 329, Specification for Agencies Engaged in the Testing and/or Inspection of Materials Used for Construction.

C. Concrete Testing Service:
   1. Employ, at own expense, testing laboratories experienced in design and testing of concrete materials and mixes to perform material evaluation tests and to design concrete mixes. The same laboratory shall not be employed to both design concrete mixes and provide field testing.
      a. Testing agency shall meet the requirements of ASTM E 329.
      b. Selection of a testing laboratory is subject to ENGINEER'S approval.
      c. Submit a written description of the proposed concrete testing laboratory giving qualifications of personnel, laboratory facilities and equipment, and other information that may be requested by ENGINEER.
   2. Materials and installed Work may require testing and retesting, as directed by ENGINEER, at any time during the progress of the Work. Allow free access to material stockpiles and facilities at all times. Tests not specifically indicated to be done at OWNER'S expense, including the retesting of rejected materials and installed Work, shall be done at CONTRACTOR'S expense.

D. Qualifications of Water-Reducing Admixture Manufacturer:
   1. Water-reducing admixtures shall be manufactured under strict quality control in facilities operated under a quality assurance program. Furnish copy of manufacturer's quality assurance handbook to document the existence of the program. Manufacturer shall maintain a concrete testing laboratory that has been approved by the Cement and Concrete Reference Laboratory at the Bureau of Standards, Washington, D.C.
   2. Provide a qualified concrete technician employed by the admixture manufacturer to assist in proportioning the concrete for optimum use of the admixture. The concrete technician shall advise on proper addition of the admixture to the concrete and on adjustment of the concrete mix proportions to meet changing jobsite conditions.

E. Laboratory Trial Batch:
   1. Each concrete mix design specified shall be verified by a laboratory trial batch, unless indicated otherwise.
   2. Each trial batch shall include the following testing:
      a. Aggregate gradation for fine and coarse aggregates.
      b. Fly ash testing to verify meeting specified properties, unless the fly ash supplier provides certification by an independent testing laboratory.
      c. Slump.
      d. Air content.
      e. Compressive strength based on three cylinders each tested at seven days and at 28 days.
      f. Shrinkage test as specified herein for Type "1" concrete mix designs.
   3. Each trial batch shall provide the following information:
      a. Project identification name and number.
      b. Date of report.

c. Complete identification of aggregate source of supply.
d. Tests of aggregates for compliance with specified requirements.
e. Scale weight of each aggregate.
f. Absorbed water in each aggregate.
g. Brand, type and composition of cement.
h. Brand, type and amount of each admixture.
i. Amounts of water used in trial mixes.
j. Proportions of each material per cubic yard.
k. Gross weight and yield per cubic yard of trial mixtures.
l. Measured slump.
m. Measured air content.
n. Compressive strength developed at seven days and 28 days, from not less than three test cylinders cast for each seven day and 28 day test, and for each design mix.
o. Shrinkage test results where required and as specified herein.

4. The requirement for a trial batch may be waived if the required test information has been provided in a previous laboratory trial batch run on the identical mix design within the previous two years. The same brand, type, and source of all materials must have been used.

F. Shrinkage Test:
1. Comply with ASTM C157 with the following modifications:
a. Prisms shall be moist cured for 7 days prior to the 28-day drying period.
b. Measurement at the end of the 7-day moist cure shall be considered the initial length.
c. The reported results shall be the average of 3 prisms.
2. If the drying shrinkage measurement of a specimen varies from the average by more than .004 percent, disregard the results from that specimen.
3. Test shrinkage characteristics every 5,000 cubic yards and every 3 months during construction of hydraulic structures.
4. Results at the end of the 28-day drying period shall not exceed 0.04 percent if 3-inch prisms are used or 0.038 percent if 4-inch prisms are used.
5. If the 7-day or 14-day field shrinkage tests exceed the limits established by testing of the mix design, furnish an additional 14 days of water cure beyond the original curing period for hydraulic structures. Modify the mix design to reduce shrinkage.

F. Certification of Concrete Mix:
1. The need for a trial batch may be waived if the following requirements are met. The compressive strength of each specified mix shall be verified by data from a series of a minimum of 30 consecutive tests that have been made within the previous 12 months. A test is defined as the average strength of all specimens of the same age fabricated from a sample taken from a single batch of concrete. All tests shall have been made on concrete which is identical in mix design to the submitted proposed mix design, including sources of aggregate and manufacturers of cementitious materials and admixtures. The tests must average

above the specified strength with no individual test falling more than 500 psi below specified strength and no three consecutive tests averaging below specified strength. In addition, the standard deviation for the series of tests shall not exceed 640 psi as defined by ACI 214.

G. Sample Panels:
   1. Provide sample panels of wall finishes, 12-inches by 12-inches by 3-inches thick. Perform revisions and corrective work required to produce finished concrete and surfaces as required by ENGINEER.
      a. Construct additional sample panels as may be required if original results are not satisfactory.
   2. The continuity of color and texture for exposed concrete surfaces is of prime importance. Maintain such controls and procedures, in addition to those specified, as is necessary to provide continuous match of concrete Work with accepted samples.

H. Mock-up Panels:
   1. Fabricate mock-up panels representative of specified finished surfaces (--1--), at locations on the site as directed by ENGINEER. Form, reinforce, mix, cast, cure and finish mock-up panels using selected materials and construction methods proposed for the Work. Provide mock-up panels as follows:
      a. Wall section of "L"-shaped panels, approximately 4 feet high by 3 feet each side by 8-inches thick and set on an 18-inch wide by 8-inch thick base, unless otherwise shown. Form faces to represent each specified formed surface finish. Include not less than two form ties, two form panel intersections, one vertical construction joint and one horizontal construction joint. Construction joints are specified in Section 03251, Concrete Joints, of these Specifications.
      b. Column section, approximately four feet high and not less than 12-inches diameter for round sections and not less than 12-inches in least dimension for rectangular sections for each specified formed finish, unless otherwise shown. Set column sections on a 6-inch thick concrete base which extends 8-inches beyond the column. Chamfer exposed edges of rectangular sample columns.
      c. Slab-on-grade section, approximately four feet square and a minimum of 4-inches thick for each applied finish, with at least one construction joint and one expansion joint, if used.
      d. Pan-formed section using at least two pan form units. Set units to illustrate method of blending exposed pan joints.
   2. Reinforce mock-up panels as required to prevent cracking and to be structurally stable or as shown on the Drawings, but reinforcing steel shall not be less than 0.25 percent of the gross concrete cross section in each direction.
   3. Protect mock-up panels from damage and do not remove them without written permission from ENGINEER. When directed, demolish mock-up panels and remove from the site.

I. Existing Sample Panels
   1. The ENGINEER will identify sections of existing concrete members which will serve as reference examples of acceptable concrete finishes.
   2. If appropriate existing concrete members do not exist to define all the finishes specified, sample sections shall be constructed as specified herein as needed.

J. Designated Finish Sample Areas
   1. The ENGINEER will identify sections of concrete members to serve as reference examples of acceptable concrete finishes from the first members constructed for each finish.
   2. At each section so designated, complete the finish as specified.
   3. Where the specified concrete finish is not obtained, the member shall be repaired to provide an acceptable finish. The construction techniques used in the next such member placed shall be adjusted to produce the required finish.
   4. Clearly mark each sample area with the name of the specified finish in such a manner that causes no damage to the finish.
   5. Protect sample sections from damage and maintain access to view such sections.

1.3 SUBMITTALS

A. Samples: Submit samples of materials as specified and as otherwise may be requested by ENGINEER, including names, sources and descriptions.

B. Shop Drawings: Submit for approval the following:
   1. Manufacturer's specifications with application and installation instructions for proprietary materials and items, including admixtures and bonding agents.
   2. List of concrete materials and concrete mix designs proposed for use. Include the results of all tests performed to qualify the materials and to establish the mix designs.
   3. The following information, if ready-mixed concrete is used.
      a. Physical capacity of mixing plant.
      b. Trucking facilities available.
      c. Estimated average amount that can be produced and delivered to the site during a normal eight hour day, excluding the output to other customers.

C. Laboratory Test Reports: Submit copies of laboratory test reports for concrete cylinders, materials and mix design tests. ENGINEER'S review will be for general information only. Production of concrete to comply with specified requirements is the responsibility of CONTRACTOR.

D. Submit notarized certification of conformance to referenced standards when requested by ENGINEER.

E. Delivery Tickets: Furnish to ENGINEER copies of all delivery tickets for each load of concrete delivered to the site. Provide items of information as specified in ASTM C 94, Section 16.1.

1. Provide batch tickets for each batch of job-site mixed concrete, as specified.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING

A. All materials used for concrete must be kept clean and free from all foreign matter during transportation and handling and kept separate until measured and placed in the mixer. Bins or platforms having hard clean surfaces shall be provided for storage. Suitable means shall be taken during hauling, piling and handling to ensure that segregation of the coarse and fine aggregate particles does not occur and the grading is not affected.

1.5 CONCRETE COORDINATION MEETING

A. A Concrete Coordination Meeting shall be held to review the detailed requirements of CONTRACTOR'S proposed concrete design mixes, to determine the procedures for producing proper concrete construction, and to clarify the roles of the parties involved shall be held no later than 14 days after the Notice to Proceed.

B. All parties involved in the concrete Work shall attend the conference, including but not limited to the following:
   1. CONTRACTOR'S representative.
   2. Testing laboratory representative.
   3. Concrete subcontractor.
   4. Reinforcing steel subcontractor and detailer.
   5. Concrete supplier.
   6. Admixture manufacturer's representative.
   7. ENGINEER.

C. The Concrete Coordination Meeting shall be held at a mutually agreed upon time and place. The ENGINEER shall be notified no less than five days prior to the date of the Concrete Coordination Meeting.

PART 2 - PRODUCTS

2.1 GENERAL

A. All admixtures, curing compounds, etc. used in concrete or the curing and repair of concrete, which can contact potable water, shall be certified as conforming to the requirements of ANSI/NSF 61 for contact with potable water when in the finished concrete.

2.2 CEMENTITIOUS MATERIALS

A. Cement:
   1. Portland cement, ASTM C 150, Type II. Type I may be used in lieu of Type II when acceptable to ENGINEER.

2. Use Portland cement made by a well-known acceptable manufacturer and produced by not more than one plant. Alternate cement sources may be used provided that a mix design has been accepted and a trial batch verifying performance has been made.
3. Do not use cement which has deteriorated because of improper storage or handling.

B. Fly Ash Mineral Admixture:
1. Mineral admixtures, when used, shall meet the requirements of ASTM C 618 Class F, except as follows:
   a. The loss on ignition shall be a maximum of 4 percent.
   b. The maximum percent of sulfur trioxide (SO3) shall be 4.0.
2. Fly ash shall be considered to be a cementitious material.
3. Laboratory trial batches shall be tested to determine compliance with strength requirements, times of setting, slump, slump loss, and shrinkage characteristics.
4. A substitution by weight, of the portland cement by fly ash, so that the total tricalcium aluminate content of the resulting cement plus fly ash is not greater than eight percent, will be considered. However, the fly ash shall not exceed 20 percent by weight of the cement plus fly ash.

C. Silica Fume Mineral Admixture:
1. Silica fume mineral admixture shall be the dry compacted or slurry form and shall meet the requirements of ASTM C 1240. Silica Fume shall be considered to be a cementitious material. Application rate shall be seven percent by weight of cement, unless indicated otherwise.
2. Product and Manufacturer: Provide one of the following:
   a. Rheomac SF100, as manufactured by Master Builders, Inc.
   b. Force 10,000 D, as manufactured by W.R. Grace & Company.
   c. Sikacrete 950 DP, as manufactured by Sika Corporation.
   d. Eucon MSA, as manufactured by the Euclid Chemical Company.
   e. Or equal.

2.3 AGGREGATES

A. General:
1. Aggregates shall conform to the requirements of ASTM C 33 and as herein specified.
2. Do not use aggregates containing soluble salts or other substances such as iron sulfides, pyrite, marcasite, ochre, or other materials that can cause stains on exposed concrete surfaces.

B. Fine Aggregate: Clean, sharp, natural sand free from loam, clay, lumps or other deleterious substances.
1. Dune sand, bank run sand and manufactured sand are not acceptable.

C. Coarse Aggregate: Clean, uncoated, processed aggregate containing no clay, mud, loam, or foreign matter, as follows:
   1. Crushed stone, processed from natural rock or stone.
   2. Washed gravel, either natural or crushed. Use of slag and pit or bank run gravel is not permitted.
   3. Lightweight Aggregate: ASTM C 330.

2.4 WATER

A. Water used in the production and curing of concrete shall be clean and free from injurious amounts of oils, acids, alkalis, organic materials or other substances that may be deleterious to concrete or steel.

2.5 CONCRETE ADMIXTURES

A. Admixtures:
   1. Manufacturers:
      a. BASF Admixtures, Inc, Shakopee, MN.
      b. Euclid Chemical Co., Cleveland, OH.
      c. W.R. Grace & Co., Cambridge, MA.
      d. Substitutions: As specified in Section 01 60 00 – Product Requirements.
   2. Air Entrainment: Comply with ASTM C260.
   3. Chemical:
      a. Comply with ASTM C494.
      b. Type A - Water Reducing.
      c. Type B - Retarding.
      d. Type C - Accelerating.
      e. Type D - Water Reducing and Retarding.
      f. Type E - Water Reducing and Accelerating.
      g. Type F - Water Reducing, High Range.
      h. Type G - Water Reducing, High Range, and Retarding.
   4. Fly Ash: Comply with ASTM C618, Class F.
   5. Silica Fume: Comply with ASTM C1240.
   6. Slag:
      a. Description: Ground-granulated blast-furnace slag.
      b. Comply with ASTM C989.
      c. Grade 100 or 120.
   7. Plasticizing:
      a. Comply with ASTM C1017.
      b. Type I or Type II.
   8. Shrinkage Reducing Admixture:
      a. BASF; Tetraguard AS20.
      b. Euclid; Eucon SRA Series.
      c. W.R. Grace; Eclipse Series.

2.6 PROPORTIONING AND DESIGN OF MIXES

Prepare concrete design mixes subject to the following limitations:

4500 psi Concrete Mix

A. Use for Hydraulic Structures not exposed to freezing and thawing cycles, moderate sulfate exposure and requiring low permeability. Typically used in water treatment in non-freeze / thaw areas.

B. Mix Design Properties:
   1. Maximum water / cementitious ratio of 0.42.
   2. Minimum compressive strength at 28 days of 4,500 psi.
   3. Conform to shrinkage limits.
   4. Air content of 3.5% to 6.0% for 3/4" maximum aggregate size and 3.0% to 5.5% for 1" maximum aggregate size.
   5. Provide cementitious materials per one of the following:
      a. ASTM C150 Type II – type F fly ash may be included as an option.
      b. ASTM C595 Type IP – complies with moderate sulfate resistance option.
   6. Minimum cementitious materials content in the mix shall be:
      a. 560 pounds per cubic yard for 3/4-inch maximum aggregate size.
      b. 535 pounds per cubic yard for 1-inch maximum aggregate size.
      c. Limit maximum cementitious content to 100 pounds per cubic yard greater than specified minimums.
   7. Limit water-soluble, chloride-ion content in hardened concrete to 0.10 percent:
      a. Test if total chloride ion content of individual ingredients, calculated on the basis of concrete proportions, exceeds 0.10 percent.

B. Lightweight Concrete: Proportion the mix as herein specified:
   1. Specified 28-day Compressive Strength: 4,000 psi.
   2. Maximum Water-Cement Ratio by Weight: 0.45.
   3. Maximum Coarse Aggregate Size: 3/4-inch to No. 4.
   4. Minimum Cement Content, pounds per cubic yard: 564.
   5. Percent Air Content: 6 ±1 percent.
   6. Dry weight of not less than 95 pcf or not more than 110 pcf after 28 days.
   7. Limit drying shrinkage to 0.05 percent at 28 days.

C. Use an independent testing facility acceptable to ENGINEER for preparing and reporting proposed mix designs.
   1. The testing facility shall not be the same as used for field quality control testing.

D. Submit written reports of laboratory trial batch test results for proposed mixes of concrete to ENGINEER at least 15 days prior to start of Work. Do not begin concrete production until mixes have been approved by ENGINEER.

E. Adjustment to Concrete Mixes: Mix design adjustments may be requested by CONTRACTOR when characteristics of materials, job conditions, weather, test results, or other circumstances warrant; at no additional cost to the OWNER and as accepted by ENGINEER. Laboratory test data for revised mix designs and strength results must be submitted to and accepted by ENGINEER before using the revised mixes.

F. Admixtures:
1. Use air-entraining admixture in all concrete, unless otherwise shown or specified. Add air-entraining admixture at the manufacturer's prescribed rate to result in concrete at the point of placement having air content within the prescribed limits.
2. Water reducing or high-range water reducing admixtures shall be used in all Type "1" concrete.
3. Use amounts of admixtures as recommended by the manufacturer for climatic conditions prevailing at the time of placing. Adjust quantities and types of admixtures as required to maintain quality control.

G. Slump Limits with High Range Water Reducer
1. Slump shall not exceed 3-inches prior to adding high range water-reducer and shall not exceed 7.5 inches, measured at point of placement, after adding high range water reducer.

H. Shrinkage Limitation
1. The maximum concrete shrinkage for specimens cast in the laboratory from the trial batch, as measured at 21-day drying age or at 28-day drying age shall be 0.039 percent or 0.045 percent, respectively. Only use a mix design for construction that has first met the trial batch shrinkage requirements. Shrinkage limitations apply only to Type "1" concretes.
2. If the trial batch results fail to meet the shrinkage limitation, the mix shall be redesigned to reduce shrinkage. Alternately, CONTRACTOR may use a higher shrinkage mix when acceptable to the ENGINEER provided that the amount of shrinkage reinforcement in the structures is increased as determined by the ENGINEER to resist the higher levels of shrinkage stresses. The additional reinforcing shall be provided at CONTRACTOR'S expense.

2.7 BONDING AGENT

A. Provide epoxy and epoxy-cement bonding agents as specified in Section 03251, Concrete Joints.

2.8 CONCRETE CURING MATERIALS

A. Absorptive Cover: Burlap cloth made from jute or kenaf, weighing approximately 10 ounces per square yard and complying with AASHTO M 182, Class 3.

B. Curing Mats: Curing mats shall be heavy carpets or cotton mats, quilted at 4-inches on center. Curing mats shall weigh a minimum of 12 ounces per square yard when dry.

C. Moisture Retaining Cover: One of the following, complying with ASTM C 171.
   1. Waterproof paper.
   2. Polyethylene film.
   3. White burlap-polyethylene sheet.

2.9 FINISHING AIDS

A. Evaporation Retardant:
   1. Product and Manufacturer: Provide one of the following:
      a. Confilm, as manufactured by Master Builders.
      b. Eucobar, as manufactured by Euclid Chemical Company.
      c. SikaFilm by Sika Corporation.
      d. Or equal.

2.10 CRACK INJECTION MATERIALS

A. Epoxy:
   1. Epoxy for injection shall be a low viscosity, high modulus moisture insensitive type.
   2. Products and Manufacturers: Provide one of the following:
      a. Sikadur 35, Hi-Mod L.V. and Sikadur 31, Hi-Mod Gel, as manufactured by Sika Corporation.
      b. Eucopoxy Injection Resin, as manufactured by The Euclid Chemical Company.
      c. Or equal.

B. Hydrophilic Resin
   1. Hydrophilic resin shall be an acrylic-ester based resin with a maximum viscosity of 50 cps. It shall cure into a flexible rubber-like material that has the potential for unrestrained increase in volume in excess of 100 percent in the presence of water.
   2. Products and Manufacturers: Provide one of the following:
      a. Duroseal Inject, as manufactured by BBZ USA, Inc.
      b. Sika Injection 29, by Sika Corporation.
      c. Or equal.

2.11 CONCRETE REPAIR MATERIALS

A. Concrete repair mortar shall be a prepackaged polymer-modified cementitious repair mortar with the following minimum properties:
   1. Compressive strength at one day: 2000 psi (ASTM C 109).
   2. Compressive strength at 28 days: 6000 psi (ASTM C 109).

3. Bond strength at 28 days: 1800 psi (ASTM C 882 modified).

B. Concrete repair mortar shall be:
1. Five Star Structural Concrete, manufactured by Five Star Products, Inc. The formulation recommended by the manufacturer for the specific application conditions shall be used.
2. SikaTop 122 Plus, SikaTop 123 Plus, SikaTop 111 Plus, or Sikacem 133, manufactured by the Sika Corporation. The formulation, among those listed, recommended by the manufacturer for the specific application conditions shall be used.
3. Emaco S88-CA or S66-CR, manufactured by Master Builders Inc. The formulation, among those listed, recommended by the manufacturer for the specific application conditions shall be used.
4. Verticoat, Verticoat Supreme, or Euco SR-VO, manufactured by the Euclid Chemical Company. The formulation, among those listed, recommended by the manufacturer for the specific application conditions shall be used.
5. Or equal.

C. Cement Mortar: Cement mortar shall consist of a mix of one part cement to 1 1/2 parts sand with sufficient water to form a trowelable consistency. Minimum compressive strength at 28 days shall be 4000 psi. Where required to match the color of adjacent concrete surfaces, white portland cement shall be blended with standard portland cement so that, when dry, the patching mortar shall match the color of the surrounding concrete.

2.14 MOISTURE BARRIER

A. Moisture Barrier: ASTM E 154:
1. Provide moisture barrier cover over prepared base material where shown on the Drawings. Use polyethylene membrane not less than 8 mils thick, lapping at least 9-inches at joints.

PART 3 - EXECUTION

3.1 INSPECTION

A. Examine the substrate and the conditions under which Work is to be performed and notify ENGINEER, in writing, of unsatisfactory conditions. Do not proceed with the Work until unsatisfactory conditions have been corrected in a manner acceptable to ENGINEER.

3.2 CONCRETE MIXING

A. General:
1. Concrete may be produced at batch plants or it may be produced by the ready-mixed process. Batch plants shall comply with the recommendations of

ACI 304, and shall have sufficient capacity to produce concrete of the qualities specified, in quantities required to meet the construction schedule. All plant facilities are subject to testing laboratory inspection and acceptance of ENGINEER.

2. Mixing:
   a. Mix concrete with an approved rotating type batch machine, except where hand mixing of very small quantities may be permitted.
   b. Remove hardened accumulations of cement and concrete frequently from drum and blades to assure acceptable mixing action.
   c. Replace mixer blades when they have lost ten percent of their original height.
   d. Use quantities such that a whole number of bags of cement is required, unless otherwise permitted.

B. Job Site Mixing: When job site mixing of concrete is permitted, mix all materials for concrete in an acceptable drum type batch machine mixer. For mixers of one cubic yard, or smaller capacity, continue mixing at least 1-1/2 minutes, but not more than five minutes after all ingredients are in the mixer, before any part of the batch is released. For mixers of capacity larger than one cubic yard, increase the minimum 1-1/2 minutes of mixing time by 15 seconds for each additional cubic yard, or fraction thereof. Do not exceed the catalog rating or Manufacturer nameplate capacity for the total volume of materials used per batch. Equip the mixer with automatic controls, or semi-automatic controls if acceptable, for proportioning materials and the proper measured quantities. Do not exceed 45 minutes total elapsed time between intermingling of damp aggregates and cement to the discharge of the completed mix.

1. Provide a batch ticket for each batch discharged and used in the Work, indicating the project identification name and number, date, mix type, mix time, quantity and amount of water introduced.

C. Ready-Mix Concrete:

1. Comply with the requirements of ASTM C 94, and as herein specified. Proposed changes in mixing procedures, other than herein specified, must be accepted by ENGINEER before implementation.
   a. Plant equipment and facilities: Conform to National Ready-Mix Concrete Association "Plant and Delivery Equipment Specification".
   b. Mix concrete in revolving type truck mixers that are in good condition and which produce thoroughly mixed concrete of the specified consistency and strength.
   c. Do not exceed the proper capacity of the mixer.
   d. Mix concrete for a minimum of two minutes after arrival at the job site, or as recommended by the mixer manufacturer.
   e. Do not allow the drum to mix while in transit.
   f. Mix at proper speed until concrete is discharged.
   g. Maintain adequate facilities at the job site for continuous delivery of concrete at the required rates.

h. Provide access to the mixing plant for ENGINEER at all times.

2. When silica fume is used in the dry compacted form, the following mix requirements shall be followed to ensure full dispersion.
   a. For all types of mixing equipment, mix times shall be increased by 40 percent over the minimum mix time required to achieve mix uniformity as defined by ASTM C 94.
   b. For truck-mixed and central mixed concrete, maximum allowable batch size shall be 80 percent of the maximum in accordance with ASTM C 94.

D. Maintain equipment in proper operating condition, with drums cleaned before charging each batch. Schedule rates of delivery in order to prevent delay of placing the concrete after mixing, or holding dry-mixed materials too long in the mixer before the addition of water and admixtures.

3.3 TRANSPORTING CONCRETE

A. Transport and place concrete not more than 90 minutes after water has been added to the dry ingredients.

B. Take care to avoid spilling and separation of the mixture during transportation.

C. Do not place concrete in which the ingredients have been separated.

D. Do not retemper partially set concrete.

E. Use suitable and approved equipment for transporting concrete from mixer to forms.

3.4 PREPARTION FOR CONCRETING

A. All reinforcement, installation of waterstop and positioning of embedded items shall be inspected and approved by the ENGINEER a minimum of four hours prior to concrete placement.

B. Subgrade surfaces shall be thoroughly wetted by sprinkling, prior to the placing of any concrete, and these surfaces shall be kept moist by frequent sprinkling up to the time of placing concrete thereon. The surface shall be free from standing water, mud, and debris at the time of placing concrete.

C. All reinforcing steel and embedded items shall be completely cleaned of mortar, loose rust, form release compounds, dirt, or any other substance which would interfere with proper bonding with concrete. Protective coatings on embedded aluminum items shall continuously cover the surface to be in contact with concrete. Any defects in the coating shall be repaired.

D. No concrete shall be placed in any structure until all water entering the space to be filled with concrete has been properly cut off or has been diverted by pipes, or other

means, and carried out of the forms, clear of the work. No concrete shall be deposited underwater nor shall CONTRACTOR allow still water to rise on any concrete until the concrete has attained its initial set. Water shall not be permitted to flow over the surface of any concrete in such manner and at such velocity as will injure the surface finish of the concrete. Pumping or other necessary dewatering operations for removing ground water, if required, will be subject to the review of the ENGINEER.

E. Joint surfaces shall be prepared as required by Section 03251, Concrete Joints.

3.5 CONCRETE PLACEMENT

A. General: Place concrete continuously so that no concrete will be placed on concrete that has hardened sufficiently to cause the formation of seams or planes of weakness within the section. If a section cannot be placed continuously, provide construction joints as specified in Section 03251, Concrete Joints. Deposit concrete as nearly as practical in its final location to avoid segregation due to rehandling or flowing. Do not subject concrete to any procedure which will cause segregation.
   1. Screed concrete that is to receive other construction to the proper level to avoid excessive skimming or grouting.
   2. Do not use concrete which becomes non-plastic and unworkable, or does not meet the required quality control limits, or which has been contaminated by foreign materials. Do not use retempered concrete. Remove rejected concrete from the job site and dispose of it in an acceptable location.
   3. Do not place concrete until all forms, bracing, reinforcement, and embedded items are in final and secure position.
   4. Unless otherwise approved, place concrete only when ENGINEER is present.
   5. Allow a minimum of three days before placing concrete against a slab or wall already in place.

B. Bonding for Next Concrete Pour:
   1. Prepare for bonding of fresh concrete to new concrete that has set but is not fully cured, as follows:
      a. Thoroughly wet the surface, but allow no free standing water.
      b. For horizontal surfaces place a 2-inch layer of mortar, one part sand and one part cement with water added to a flowable consistency, or a 6-inch layer of Construction Joint Grout, as specified in Section 03600, Grout, over the hardened concrete surface.
      c. Place fresh concrete before the mortar/grout has attained its initial set.
      d. If a high range water reducer is used to increase the concrete slump to at least 6-inches, the mortar/grout layer may be omitted.
   2. Bonding of fresh concrete to fully-cured hardened existing concrete shall be accomplished by using a bonding agent as specified in Section 03251, Concrete Joints.

C. Concrete Conveying:

1. Handle concrete from the point of delivery and transfer to the concrete conveying equipment and to the locations of final deposit as rapidly as practical by methods that will prevent segregation and loss of concrete mix materials.
2. Provide mechanical equipment for conveying concrete to ensure a continuous flow of concrete at the delivery end. Provide runways for wheeled concrete conveying equipment from the concrete delivery point to the locations of final deposit. Keep interior surfaces of conveying equipment, including chutes, free of hardened concrete, debris, water, ice and other deleterious materials.
3. Do not use chutes for distributing concrete, unless approved in writing by ENGINEER.
   a. Provide sketches showing methods by which chutes will be employed when requesting such approval.
   b. Design chutes, if permitted, with proper slopes and supports to permit efficient handling of the concrete.
4. Pumping concrete is permitted, however do not use aluminum pipe for conveying.

D. Placing Concrete into Forms:
1. Deposit concrete in forms in horizontal layers not deeper than 18-inches and in a manner to avoid inclined construction joints. Where placement consists of several layers, place concrete at such a rate that concrete that is being integrated with fresh concrete is still plastic.
2. Do not permit concrete to free fall within the form from a distance exceeding four feet. Where high range water reducer is used to extend slump to at least 6-inches, the maximum free fall of concrete may be increased to six feet. If a 12-inch thick layer of construction joint grout, as specified in Section 03251, Concrete Joints, is placed on the horizontal joint, concrete with slump extended by a high range water reducer may free fall up to eight feet in walls that are 24-inches and thicker. Use "elephant trunks" to prevent free fall and excessive splashing on forms and reinforcement. Free falls in excess of four feet shall be discontinued if there is any evidence of segregation.
3. Remove temporary spreaders in forms when concrete placing has reached the elevation of such spreaders.
4. Consolidate concrete placed in forms by mechanical vibrating equipment supplemented by hand-spading, rodding or tamping. Use equipment and procedures for consolidation of concrete in accordance with the applicable recommended practices of ACI 309. Vibration of forms and reinforcing will not be permitted, unless otherwise accepted by ENGINEER.
5. Where height of concrete placement in walls exceeds 14 feet, temporary windows shall be installed in the formwork to facilitate vibration. The windows shall be properly closed when the height of concrete approaches the windows. Location, size, and spacing of the windows shall be determined by CONTRACTOR to suit equipment used.
6. Do not use vibrators to transport concrete inside of forms. Insert and withdraw vibrators vertically at uniformly spaced locations not farther than the visible effectiveness of the machine. Place vibrators to rapidly penetrate the layer of

concrete and at least 6-inches into the preceding layer. Do not insert vibrators into lower layers of concrete that have begun to set. At each insertion, limit the duration of vibration to the time necessary to consolidate the concrete and complete embedment of reinforcement and other embedded items without causing segregation of the mix.

7. Do not place concrete in beam and slab forms until the concrete previously placed in columns and walls is no longer plastic.
8. Force concrete under pipes, sleeves, openings and inserts from one side until visible from the other side to prevent voids.

E. Placing Concrete Slabs:
   1. Deposit and consolidate concrete slabs in a continuous operation, within the limits of construction joints, until the placing of a panel or section is completed.
   2. Consolidate concrete during placing operations using mechanical vibrating equipment, so that concrete is thoroughly worked around reinforcement and other embedded items and into corners.
   3. Consolidate concrete placed in beams and girders of supported slabs, and against bulkheads of slabs on ground, as specified for formed concrete structures.
   4. Bring slab surfaces to the correct level. Smooth the surface, leaving it free of humps or hollows. Do not sprinkle water on the plastic surface. Do not disturb the slab surfaces prior to beginning finishing operations.
   5. Where slabs are placed in conditions of high temperature or wind that could lead to formation of plastic shrinkage cracks, an evaporation retardant shall be applied in accordance with the manufacturer's recommendations, when required by the ENGINEER.

F. Quality of Concrete Work:
   1. Make all concrete solid, compact and smooth, and free of laitance, cracks and cold joints.
   2. All concrete for liquid retaining structures, and all concrete in contact with earth, water, or exposed directly to the elements shall be watertight.
   3. Cut out and properly replace to the extent directed by ENGINEER, or repair to the satisfaction of ENGINEER, surfaces which contain cracks or voids, are unduly rough, or are in any way defective. Thin patches or plastering shall not be acceptable.
   4. All leaks through concrete that exhibit any flowing water, and cracks, holes or other defective concrete in areas of potential leakage, shall be repaired and made watertight by CONTRACTOR.
   5. Repair, removal, and replacement of defective concrete as directed by ENGINEER shall be at no additional cost to the OWNER.

G. Cold Weather Placing:
   1. Protect all concrete Work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures, in compliance with the requirements of ACI 306 and as herein specified.

2. When the air temperature has fallen to or may be expected to fall below 40°F, provide adequate means to maintain the temperature, in the area where concrete is being placed, at between 50°F and 70°F for at least seven days after placing. Provide temporary housings or coverings including tarpaulins or plastic film. Maintain the heat and protection, if necessary, to ensure that the ambient temperature does not fall more than 30°F in the 24 hours following the seven-day period. Avoid rapid dry-out of concrete due to overheating, and avoid thermal shock due to sudden cooling or heating.
3. When air temperature has fallen to or is expected to fall below 40°F, uniformly heat all water and aggregates before mixing as required to obtain a concrete mixture temperature of not less than 55°F and not more than 85°F at point of placement.
4. Do not use salt and other materials containing antifreeze agents or chemical accelerators, or set-control admixtures, unless approved by ENGINEER, in mix designs.

H. Hot Weather Placing:
1. When hot weather conditions exist that would seriously impair the quality and strength of concrete, place concrete in compliance with ACI 305 and as herein specified.
2. When ambient air temperature is at or above 90°F, cool ingredients before mixing to maintain concrete temperature at time of placement below 80°F when the air temperature is rising and below 85°F when the air temperature is falling. Mixing water may be chilled, or chopped ice may be used to control the concrete temperature provided the water equivalent of the ice is calculated in the total amount of mixing water. In addition, the reduction in time from addition of mix water to placement or the use of a set retarding admixture may be required.
3. Cover reinforcing steel with water-soaked burlap if it becomes too hot, so that the steel temperature will not exceed the ambient air temperature immediately before embedment in concrete.
4. Wet forms thoroughly before placing concrete.
5. Do not place concrete at a temperature so as to cause difficulty from loss of slump, flash set, or cold joints.
6. Do not use set-control admixtures, unless approved by ENGINEER in mix designs.
7. Obtain ENGINEER'S approval of other methods and materials proposed for use.

3.6 FINISH OF FORMED SURFACES

A. Standard Form Finish:
1. Standard form finish shall be basically smooth and even but shall be permitted to have texture imparted by the form material used. Defects shall be repaired as specified herein.
2. Use standard form finish for the following:
a. Exterior vertical surfaces from the foundation up to one foot below grade.

b. Vertical surfaces not exposed to view.
c. Other areas shown.

B. Smooth Form Finish:
1. Produce smooth form finish by selecting form materials that will impart a smooth, hard, uniform texture. Arrange panels in an orderly and symmetrical manner with a minimum of seams. Repair and patch defective areas as specified herein.
2. Use smooth form finish for the following:
a. Exterior surfaces that are exposed to view.
b. Surfaces that are to be covered with a coating material. The material may be applied directly to the concrete or may be a covering bonded to the concrete such as waterproofing, dampproofing, painting or other similar system.
c. Interior vertical surfaces of liquid containers.
d. Interior and exterior exposed beams and undersides of slabs.
e. Surfaces to receive an abrasive blasted finish.
f. Surfaces to receive a smooth rubbed or grout cleaned finish.
g. Other areas shown.

C. Smooth Rubbed Finish:
1. Provide smooth, Class A, rubbed finish to concrete surfaces, which have received smooth form finish and where all defects have been repaired, as follows:
a. Rubbing of concrete surfaces not later than the day after form removal.
b. Moistening of concrete surfaces and rubbing with carborundum brick or other abrasive until a uniform color and texture is produced. Do not apply cement grout other than that created by the rubbing process.
2. Except where surfaces have been previously covered as specified above, use smooth, Class A, rubbed finish for the following:
a. Interior exposed walls and other vertical surfaces.
b. Exterior exposed walls and other vertical surfaces down to one foot below grade.
c. Interior and exterior horizontal surfaces, except exterior exposed slabs and steps.
d. Interior exposed vertical surfaces of liquid containers down to one foot below liquid level.
e. Other areas shown on the Drawings.

D. Grout Cleaned Finish:
1. Provide grout cleaned finish to concrete surfaces, which have received smooth form finish and where all defects have been repaired, as follows:
a. Combine one part portland cement to 1-1/2 parts fine sand by volume, and mix with water to the consistency of thick paint. Blend standard portland cement and white portland cement, amounts determined by trial patches, so

that the final color of dry grout will closely match adjacent concrete surfaces.

b. Thoroughly wet the concrete surface and apply grout uniformly by brushing or spraying immediately to the wetted surfaces. Scrub surface with cork float or stone to coat surface and fill surface holes. Remove excess grout by scraping, followed by rubbing with clean burlap to remove any visible grout film. Keep grout damp during the setting period by means of fog spray at least 36 hours after final rubbing. Complete any area in the same day it is started, with the limits of any area being natural breaks in the finished surface.

2. Except where surfaces have been previously covered as specified above, use grout cleaned finish for the following:
   a. Interior exposed walls and other vertical surfaces.
   b. Exterior exposed walls and other vertical surfaces down to one foot below grade.
   c. Interior and exterior horizontal surfaces, except exterior exposed slabs and steps.
   d. Interior exposed vertical surfaces of liquid containers down to one foot below liquid level.
   e. Other areas shown on the Drawings.

E. Abrasive Blasted Finish
   1. Provide abrasive blasted finish where shown.
   2. Where abrasive blasted finish is indicated, it shall be applied to a smooth formed finish after the end of the curing period, with all defects repaired, to match the approved finish provided on the mock-up panel.
   3. Heavy Abrasive Blasted Finish: Abrasive blast to uniformly expose coarse aggregate.
   4. Light Abrasive Blasted Finish: Abrasive blast to uniformly expose fine aggregate.

F. Related Unformed Surfaces:
   1. At tops of walls, horizontal offsets, and similar unformed surfaces occurring adjacent to formed surfaces, strike off smooth and finish with a texture matching the adjacent formed surfaces. Continue the final surface treatment of formed surfaces uniformly across the adjacent unformed surfaces, unless otherwise shown.

3.7 SLAB FINISHES

A. Float Finish:
   1. After placing concrete slabs, do not work the surface further until ready for floating. Begin floating when the surface water has disappeared or when the concrete has stiffened sufficiently. Check and level the surface plane to a tolerance not exceeding 1/4-inch in ten feet when tested with a ten foot straightedge placed on the surface at not less than two different angles. Cut

down high spots and fill all low spots. Uniformly slope surfaces to drains. Immediately after leveling, refloat the surface to a uniform, smooth, granular texture.

2. Use float finish for the following:
   a. Interior exposed horizontal surfaces of liquid containers, except those to receive grout topping.
   b. Exterior below grade horizontal surfaces.
   c. Surfaces to receive additional finishes, except as shown or specified.

B. Trowel Finish:
1. After floating, begin the first trowel finish operation using a power-driven trowel. Begin final troweling when the surface produces a ringing sound as the trowel is moved over the surface.
2. Consolidate the concrete surface by the final hand troweling operation. Finish shall be free of trowel marks, uniform in texture and appearance, and with a surface plane tolerance not exceeding 1/8-inch in ten feet when tested with a ten foot straight edge. Grind smooth surface defects that would telegraph through applied floor covering system.
3. Use trowel finish for the following:
   a. Interior exposed slabs, unless otherwise shown or specified.
   b. Slabs to receive resilient floor finishes.

C. Non-Slip Broom Finish:
1. Immediately after float finishing, slightly roughen the concrete surface by brooming in the direction perpendicular to the main traffic route. Use fine fiber-bristle broom, unless otherwise directed by the ENGINEER. Coordinate the required final finish with ENGINEER before application.
2. Use Non-Slip Broom Finish for the following:
   a. Exterior exposed horizontal surfaces subject to light foot traffic.
   b. Interior and exterior concrete steps and ramps.
   c. Horizontal surfaces which will receive a grout topping or a concrete equipment base slab.

D. Shake-On Metallic Finish:
1. All slabs as shown, shall receive an application of shake-on metallic hardener at the rate of two pounds per square foot. The first shake shall comprise 2/3 of the specified amount of hardener. This application shall be made after the initial floating operation, unless climatic conditions dictate earlier application. The shake-on metallic hardener shall be floated in the second application made. The surface shall be floated again sufficiently to properly bond the hardener to the base concrete slab. The surface shall then be troweled, at least twice, to a smooth dense finish.
2. Field service shall be provided, upon five days notice by the manufacturer of the hardener to assist CONTRACTOR in obtaining the maximum benefits of the product under the prevailing jobsite conditions. In addition, the representative shall attend the Concrete Coordination Meeting.

3. Use shake-on metallic hardener finish with Type "3" concrete for slabs where noted on Drawings.
4. Protect slabs against oil and greases. Remove all dripping, flaking or loose substances and any other bonded foreign particles from slab surface that might prevent adhesion of composition.
5. Do not patch or otherwise work on damaged or imperfect floors without first coordinating with applicator.

3.8 CONCRETE CURING AND PROTECTION

A. General:
1. Protect freshly placed concrete from premature drying and excessive cold or hot temperature, and maintain without drying at a relatively constant temperature for the period of time necessary for hydration of the cement and proper hardening of the concrete.
2. Start initial curing after placing and finishing concrete as soon as free moisture has disappeared from the concrete surface. Keep continuously moist for not less than 72 hours.
3. Begin final curing procedures immediately following initial curing and before the concrete has dried. Continue final curing for at least seven days and in accordance with ACI 301 procedures for a total curing period, initial plus final, of at least ten days. For concrete sections over 30-inches thick, continue final curing for an additional seven days, minimum. Avoid rapid drying at the end of the final curing period.

B. Curing Methods:
1. Water retaining and below grade structures shall be moist cured by the addition of water to maintain the surface in a continually wet condition. Other concrete shall be cured by moist curing, by moisture retaining cover curing, or by the use of curing compound. Use curing compound at water retaining and below grade structures only in cold weather and only when permitted by ENGINEER.
   a. For curing, use water that is free of impurities that could etch or discolor exposed, natural concrete surfaces.
2. Provide moisture curing by any of the following methods:
   a. Keeping the surface of the concrete continuously wet by covering with water.
   b. Continuous water-fog spray.
   c. Covering the concrete surface with curing mats, thoroughly saturating the mats with water, and keeping the mats continuously wet with sprinklers or porous hoses. Place curing mats so as to provide coverage of the concrete surfaces and edges, with a 4-inch lap over adjacent mats. If necessary, the curing cover shall be weighted to maintain contact with the concrete surface.
   d. At the end of the curing period apply one coat of curing compound, unless concrete surface is to receive a topping or coating or application is waived by the ENGINEER.

3. Provide moisture retaining cover curing as follows:
   a. Cover the concrete surfaces with the specified moisture retaining cover for curing concrete, placed in the widest practical width with sides and ends lapped at least 3-inches and sealed by waterproof tape or adhesive. Immediately repair any holes or tears during the curing period using cover material and waterproof tape.
4. Provide liquid curing compound as follows:
   a. Apply the specified curing compound to all concrete surfaces when permitted by ENGINEER. Slabs to receive terrazzo floors, chemical resistant heavy duty concrete topping or ceramic tile, shall not be cured with liquid curing compound, but shall be moisture cured. The compounds shall be applied immediately after final finishing in a continuous operation by power spray equipment in accordance with the manufacturer's directions. Recoat areas that are subjected to heavy rainfall within three hours after initial application. Maintain the continuity of the coating and repair damage to the coat during the entire curing period. For concrete surfaces that will be in contact with potable water, the manufacturer shall certify that the curing compound meets the requirements of ANSI/NSF 61.
   b. When curing compound is authorized for application to water retaining or below grade members, it shall be applied at the manufacturer's recommended coverage rate and then applied again at the same rate to provide twice the recommended coverage.
   c. At the end of the curing period, curing compound shall be removed where required by the ENGINEER.

C. Curing Formed Surfaces:
   1. Cure formed concrete surfaces; including the undersides of girders, beams, supported slabs and other similar surfaces by moist curing with the forms in place unloosened for the full curing period or until forms are removed. Where wood forms are kept in place, water shall be added to keep the forms wet. If forms are removed, continue curing by methods specified above, as applicable.

D. Curing Unformed Surfaces:
   1. Initially cure unformed surfaces, such as slabs, floor topping, and other flat surfaces by using the appropriate method specified above.
   2. Final cure unformed surfaces, unless otherwise specified, by utilizing methods specified above, as applicable.

E. Temperature of Concrete During Curing:
   1. When the atmospheric temperature is 40°F and below, maintain the concrete temperature between 50°F and 70°F continuously throughout the curing period. When necessary, make arrangement before concrete placing for heating, covering, insulation or housing as required to maintain the specified temperature and moisture conditions continuously for the concrete curing period. Provide cold weather protection complying with the requirements of ACI 306.

2. When the atmospheric temperature is 80°F and above, or during other climatic conditions which will cause too rapid drying of the concrete, make arrangements before the start of concrete placing for the installation of wind breaks or shading, and for fog spraying, wet sprinkling, or moisture retaining covering. Protect the concrete continuously for the concrete curing period. Provide hot weather protection complying with the requirements of ACI 305, unless otherwise specified.
3. Maintain concrete temperature as uniformly as possible, and protect from rapid atmospheric temperature changes. Avoid temperature changes in concrete which exceed 5°F in any one hour and 50°F in any 24 hour period.

F. Protection from Mechanical Injury:
1. During the curing period, protect concrete from damaging mechanical disturbances including load stresses, heavy shock, excessive vibration, and from damage caused by rain or flowing water. Protect all finished concrete surfaces from damage by subsequent construction operations.

3.9 FIELD QUALITY CONTROL

A. The OWNER shall employ a testing laboratory to perform field quality control testing. ENGINEER will direct the number of tests and cylinders required. Make standard compression test cylinders and entrained air tests as specified below, under the direct inspection by ENGINEER. Also, provide all labor, material and equipment required including, scale, glass tray, cones, rods, molds, air tester, thermometer, curing in a heated storage box, and all other incidentals required. Above will be subject to approval by ENGINEER. Furnish all necessary storage and curing, as specified in Section 01450, On-Site Facilities for Testing Laboratory, and transportation required by the testing.

B. Quality Control Testing During Construction:
1. Perform sampling and testing for field quality control during the placement of concrete, as follows:
   a. Sampling Fresh Concrete: ASTM C 172.
   b. Slump: ASTM C 143; one test for each concrete load at point of discharge; and one for each set of compressive strength test specimens.
   c. Air Content: ASTM C 231; one for every other concrete load at point of discharge, or when required by an indication of change.
   d. Compressive Strength Tests: ASTM C 39; one set of compression cylinders for each 50 cubic yards or fraction thereof, of each mix design placed in any one day; one specimen tested at seven days, and three specimens tested at 28 days.
      1) Adjust mix if test results are unsatisfactory and resubmit for ENGINEER'S approval.
      2) Concrete that does not meet the strength requirements is subject to rejection and removal from the Work, or to other such corrective

measures as directed by ENGINEER, at the expense of CONTRACTOR.

e. Compression Test Specimens: ASTM C 31; make one set of four standard cylinders for each compressive strength test, unless otherwise directed.
   1) Cast, store and cure specimens as specified in ASTM C 31.

f. Concrete Temperature: Test hourly when air temperature is 40°F and below, and when 80°F and above; and each time a set of compression test specimens is made.

2. The testing laboratory shall submit certified copies of test results directly to ENGINEER and CONTRACTOR within 24 hours after tests are made.

C. Evaluation of Quality Control Tests:

1. Do not use concrete delivered to the final point of placement, which has slump or total air content outside the specified values.
2. When water content testing indicates water-cementitious materials ratio to exceed specified requirements by more than 0.02, remaining batches needed to complete the concrete placement shall have water content decreased in the mix and water reducing admixture dosage increased as needed to bring the subsequently batched concrete within the specified water-cementitious materials ratio. Additional testing shall be done to verify compliance with the specified water-cementitious materials ratio. Concrete production for further concrete placements shall not resume until CONTRACTOR has identified the cause of the excess water in the mix and revised batching procedures and/or adjustments to mix design needed to bring water-cementitious materials ratio into conformance with specified requirements have been accepted by Engineer.
3. Compressive strength tests for laboratory-cured cylinders will be considered satisfactory if the averages of all sets of three consecutive compressive strength tests results equal or exceed the 28 day design compressive strength of the type or class of concrete; and, no individual strength test falls below the required compressive strength by more than 500 psi.
   a. Where questionable field conditions may exist during placing concrete or immediately thereafter, strength tests of specimens cured under field conditions will be required by ENGINEER to check the adequacy of curing and protecting of the concrete placed. Specimens shall be molded at the same time and from the same samples as the laboratory cured specimens.
      1) Provide improved means and procedures for protecting concrete when the 28 day compressive strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders.
      2) When laboratory-cured cylinder strengths are appreciably higher than the minimum required compressive strength, field-cured cylinder strengths need not exceed the minimum required compressive strength by more than 500 psi even though the 85 percent criterion is not met.
      3) If individual tests of laboratory-cured specimens produce strengths more than 500 psi below the required minimum compressive strength, or if tests of field-cured cylinders indicate deficiencies in protection and curing, provide additional measures to assure that the load-bearing

capacity of the structure is not jeopardized. If the likelihood of low-strength concrete is confirmed and computations indicate the load-bearing capacity may have been significantly reduced, tests of cores drilled from the area in question will be required at CONTRACTOR'S expense.

b. If the compressive strength tests fail to meet the minimum requirements specified, the concrete represented by such tests will be considered deficient in strength and subject to replacement, reconstruction or to other action approved by ENGINEER.

D. Testing Concrete Structure for Strength:
1. When there is evidence that the strength of the in-place concrete does not meet specification requirements, employ at CONTRACTOR'S expense the services of a concrete testing service to take cores drilled from hardened concrete for compressive strength determination. Tests shall comply with the requirements of ASTM C 42 and the following:
   a. Take at least three representative cores from each member or suspect area at locations directed by ENGINEER.
   b. Strength of concrete for each series of cores will be considered satisfactory if their average compressive strength is at least 85 percent and no single core is less than 75 percent of the 28 day required compressive strength.
   c. Report test results to ENGINEER, in writing, on the same day that tests are made. Include in test reports, the Project identification name and number, date, name of CONTRACTOR, name of concrete testing service, location of test core in the structure, type or class of concrete represented by core sample, nominal maximum size aggregate, design compressive strength, compression breaking strength and type of break (corrected for length-diameter ratio), direction of applied load to core with respect to horizontal plane of the concrete as placed, and the moisture condition of the core at time of testing.
2. Fill core holes solid with non-shrink, high strength grout, and finish to match adjacent concrete surfaces.
3. Conduct static load test and evaluations complying with the requirements of ACI 318 if the results of the core tests are unsatisfactory, or if core tests are impractical to obtain, as directed by ENGINEER.

3.10 MISCELLANEOUS CONCRETE ITEMS

A. Temporary Openings
1. Openings in concrete walls and/or slabs required for passage of Work or installation of equipment and not shown on the Drawings shall be provided, but only with approval of the ENGINEER.
2. All temporary openings made in concrete shall be provided with waterstop in below grade or water retaining members. Continuity of required reinforcement shall be provided in a manner acceptable to the ENGINEER.

3. Temporary openings left in concrete structures shall be filled with concrete after the Work causing the need for the opening is in place, unless otherwise shown or directed. Mix, place and cure concrete as specified herein, to blend with in-place construction. Provide all other miscellaneous concrete filling shown or required to complete the Work.

B. Equipment Bases:
1. Unless specifically shown otherwise, provide concrete bases for all pumps and other equipment. Coordinate and construct bases to the dimensions shown, or as required to meet manufacturers; requirements and Drawing elevations. Where no specific elevations are shown, bases shall be 6-inches thick and extend 3-inches outside the metal equipment base or supports. Bases shall have smooth trowel finish, unless a special finish such as terrazzo, ceramic tile or heavy duty concrete topping is required. In those cases, provide appropriate concrete finish.
2. Include all concrete equipment base work not specifically included under other Sections.
3. In general, place bases up to 1-inch below the metal base. Properly shim equipment to grade and fill 1-inch void with non-shrink grout as specified in Section 03600, Grout.

C. Curbs:
1. Provide monolithic finish to interior curbs by stripping forms while concrete is still green and steel-troweling surfaces to a hard, dense finish with corners, intersections, and terminations slightly rounded.
2. Exterior curbs shall have rubbed finish for vertical surfaces and a broomed finish for top surfaces.

D. Steel Pan Stairs:
1. Provide concrete fill for steel pan stair treads and landings and associated items. Screed, tamp, and finish concrete surfaces as shown.
   a. Cast-in safety inserts and accessories as shown.

E. Slabs/Foundations:
1. All mechanical pipe and electrical conduit penetrations through concrete slabs must be sleeved.

3.11 CONCRETE REPAIRS

A. Repair of Formed Surfaces:
1. The following defects shall be repaired in all types of formed finishes:
   a. Spalls, air bubbles, rock pockets, form depressions, and other defects that are more than 1/4-inch in depth.
   b. Holes from tie rods and other form tie systems.
   c. Fins, offsets and other projections that extend more than 1/4-inch beyond the designated member surface.
   d. Structural cracks, as defined by the ENGINEER.

e. Non-structural cracks, as defined by the ENGINEER, which are greater than 0.010-inch wide. In water retaining members, elevated slabs subject to rainfall and washdown, and below grade members, any crack that shows any amount of leakage. Where it is not possible to verify that a crack is not leaking, it shall be repaired.

2. The following defects shall be repaired in smooth finish surfaces, in addition to those listed above:
   a. Spalls, air bubbles, rock pockets, form depressions, and other defects which extend to more than 1/2-inch in width in any direction, no matter how deep.
   b. Spalls, air bubbles, rock pockets, form depressions, and other defects of any size that exceed three in number in a 12-inch square or 12 in number in a three foot square.
   c. Fins, offsets and other projections shall be completely removed and smoothed.
   d. Scratches and gouges in the surface.
   e. Texture and color irregularities. At water retaining surfaces, texture and color irregularities need not be repaired when greater than 12-inches below the minimum normal operating water surface, except where such defects are indicative of reduced durability.
3. Where a smooth rubbed or grout cleaned finish is specified, minor surface defects repairable by the finishing process need not be repaired prior to the finish application, when approved by the ENGINEER.

B. Method of Repair of Formed Surfaces:
1. Repair and patch defective areas with cement mortar or concrete repair mortar immediately after removal of forms and as directed by ENGINEER. Repairs made to water bearing and buried surfaces shall be made with repair mortar only. Repairs of form tie holes on water bearing or buried surfaces shall be made with non-shrink grout as specified in Section 03600, Grout.
2. Cut out honeycomb, rock pockets, voids, and holes left by tie rods and bolts, down to solid concrete but, in no case, to a depth of less than 1-inch for cement mortar and 1/2-inch for repair mortar. Make edges of cuts perpendicular to the concrete surface. Before placing the cement mortar, thoroughly clean and brush-coat the area to be patched with the specified bonding agent. Where concrete repair mortar is used, bonding agent shall be optional and the surface prepared and mortar placed per manufacturers recommendations.
   a. Repairs at exposed-to-view surfaces shall match the color of surrounding concrete, except color matching is not required for the interior surfaces of liquid containers up to one foot below liquid level. Impart texture to repaired surfaces to match texture of existing adjacent surfaces. Provide test areas at inconspicuous locations to verify mixture, texture and color match before proceeding with the patching. Compact mortar in place and strike off slightly higher than the surrounding surface.
3. Structural cracks shall be pressure grouted using an injectable epoxy using a pumped pressure system. Apply in accordance with the manufacturer's directions and recommendations.

4. Non-structural cracks shall be pressure grouted using hydrophilic resin. Apply in accordance with the manufacturer's directions and recommendations.
5. Determination of the crack type shall be made by the ENGINEER.
6. Fill holes extending through concrete by means of a plunger- type gun or other suitable device from the least exposed face, using a flush stop held at the exposed face to ensure completely filling. At below grade and water retaining members, fill holes with concrete repair mortar except use a color matched cement mortar for the outer 2-inches at exposed to view surfaces.
7. Where powerwashing and/or scrubbing is not adequate, abrasive blast exposed-to-view surfaces that require removal of stains, grout accumulations, sealing compounds, and other substances marring the surfaces. Use sand finer than No. 30 and air pressure from 15 to 25 psi.

C. Repair of Unformed Surfaces:
1. Test unformed surfaces, such as monolithic slabs, for smoothness and to verify surface plane to the tolerances specified for each surface and finish. Correct low and high areas as herein specified.
2. Test unformed surfaces sloped to drain for trueness of slope, in addition to smoothness, using a template having the required slope. Correct high and low areas as herein specified.
3. Repair finish of unformed surfaces that contain defects that adversely affect the durability of the concrete. Surface defects include crazing, cracks in excess of 0.01-inch wide, spalling, popouts, honeycomb, rock pockets, and other objectionable conditions.
4. Repair structural cracks in all structures and non-structural cracks in water-holding structures. In water-holding structures, where the dry face of the concrete member can be observed, cracks that show any rate of water flow shall be repaired. Where the dry face of the member cannot be observed, all cracks shall be repaired.

D. Methods of Repair of Unformed Surfaces:
1. Correct high areas in unformed surfaces by grinding, after the concrete has cured sufficiently so that repairs can be made without damage to adjacent areas.
2. Correct low areas in unformed surfaces during, or immediately after completion of surface finishing operations by cutting out the low areas and replacing with fresh concrete. Finish repaired areas to blend into adjacent concrete. Where the concrete has already set and repairs are required, sawcut around the perimeter of the area to be repaired to a 1/2-inch depth and remove concrete so that the minimum thickness of the repair is 1/2-inch. Apply specified concrete repair mortar in accordance with the manufacturer's directions and recommendations.
3. Repair defective areas, except random cracks and single holes not exceeding 1-inch diameter, by cutting out and replacing with fresh concrete. Remove defective areas to sound concrete with clean, square cuts, and expose reinforcing steel with at least 3/4-inch clearance all around. The minimum thickness of the repair shall be 1.5-inches. Dampen all concrete surfaces in contact with patching concrete and brush with the specified bonding agent. Place patching

concrete while the bonding agent is still tacky. Mix patching concrete of the same materials and proportions to provide concrete of the same classification as the original adjacent concrete. Place, compact and finish as required to blend with adjacent finished concrete. Cure in the same manner as adjacent concrete.

4. Repair isolated random non-structural cracks (in members which are not below grade or water retaining), and single holes not over 1-inch diameter, by the dry-pack method. Groove the top of cracks, and cut out holes to sound concrete and clean of dust, dirt and loose particles. Dampen all cleaned concrete surfaces and brush with the specified bonding agent. Place dry-pack before the cement grout takes its initial set. Mix dry-pack, consisting of one part portland cement to 2-1/2 parts fine aggregate passing a No. 16 mesh sieve, using only enough water as required for handling and placing. Compact dry-pack mixture in place and finish to match adjacent concrete. Keep patched areas continuously moist for not less than 72 hours.
5. Structural cracks shall be pressure grouted using an injectable epoxy. Apply in accordance with the manufacturer's directions and recommendations.
6. Non-structural cracks in below grade and water retaining structures shall be pressure grouted using hydrophilic resin. Apply in accordance with the manufacturer's directions and recommendations.
7. Determination of the crack type shall be made by the ENGINEER.
8. Assure that surface is acceptable for flooring material to be installed in accordance with manufacturer's recommendations.

E. Other Methods of Repair:
   1. Repair methods not specified above may be used if approved by ENGINEER.

+ + END OF SECTION + +

SECTION 03600

GROUT

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment, and incidentals as shown, specified and required to furnish and install grout.
   2. The types of grout include the following:
      a. Non-Shrink Grout: This type of grout is to be used wherever grout is shown in the Contract Documents, unless another type is specifically referenced. Two classes of non-shrink grout (Class I and II) and areas of application are specified herein.
      b. Non-Shrink Epoxy Grout (Class III).
      c. Grout Fill, Topping Grout.
      d. Construction Joint Grout.

B. Application: The following is a listing of typical applications and the corresponding type of grout which is to be used. Unless indicated otherwise, grouts shall be provided as listed below whether called for on the Drawings or not.

Application	Type of Grout
Beam and column (1 or 2 story) base plates and precast concrete bearing less than 16-inches in the least dimension.	Non-shrink Class II
Column base plates and precast concrete bearing (greater than 2 story or larger than 16- inches in the least dimension).	Non-shrink Class I
Base plates for storage tanks and other non-motorized equipment and machinery less than 30 horsepower.	Non-shrink Class I
Machinery over 30 horsepower and equipment under 30 horsepower but subject to severe shock loads and high vibration.	Non-shrink Class III
Filling blockout spaces for embedded items such as railing posts, gate guide frames, etc.	Non-shrink Class II (Class I where placement time exceeds 15 minutes)

Toppings and concrete fill less than 4-inches thick.	Grout Fill, Topping Grout
Toppings and concrete fill greater than 4-inches thick.	Type "1" Concrete in accordance with Section 03300, Cast-In-Place Concrete.
All anchor bolts and reinforcing steel set in grout.	Refer to Section 03200, Concrete Reinforcement, and Section 05051, Anchor Bolts, Toggle Bolts and Concrete Inserts.
Any application not listed above, where grout is called for on the Drawings.	Non-shrink Class I, unless noted otherwise

1.2 QUALITY ASSURANCE

A. Reference Standards: Comply with applicable provisions and recommendations of the following, except as otherwise shown or specified.
   1. ACI 211.1, Practice for Selecting Proportions for Normal, Heavy-Weight and Mass Concrete.
   2. ACI 301, Specification for Structural Concrete (Includes ASTM Standards referred to herein).
   3. ASTM C33, Specification for Concrete Aggregates.
   4. ASTM C109, Test Method for Compressive Strength of Hydraulic Cement Mortars (using 2-in. or 50 mm. Cube Specimens).
   5. ASTM C150, Specification for Portland Cement.
   6. ASTM C230, Specification for Flow Table for use in Tests of Hydraulic Cement.
   7. ASTM C531, Test Method for Linear Shrinkage and Coefficient of Thermal Expansion of Chemical- Resistant Mortars, Grouts, and Monolithic Surfacings.
   8. ASTM C579, Test Method for Compressive Strength of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings and Polymer Concretes.
   9. ASTM C827, Test Method for Early Volume Change of Cementitious Mixtures.
   10. ASTM C882, Test Method for Bond Strength of Epoxy-Resin Systems Used with Concrete.
   11. ASTM C937, Specification for Grout Fluidifier for Preplaced-Aggregate Concrete.
   12. ASTM C939, Text Method for Flow of Grout for Preplaced-Aggregate Concrete (Flow Cone Method).
   13. ASTM C1107, Specification for Packaged Dry, Hydraulic-Cement Grout (Non-shrink).
   14. ASTM C1181, Test Method for Compressive Creep of Chemical-Resistant Polymer Machinery Grouts.

15. ASTM D696, Test Method for Coefficient of Linear Thermal Expansion of Plastics.

B. Field Tests:
   1. Compression test specimens will be taken during construction from the first placement of each type of grout, and at intervals thereafter as selected by the ENGINEER to ensure continued compliance with these specifications. The specimens will be made by the ENGINEER or its representative.
   2. Compression tests and fabrication of specimens for non-shrink grout will be performed as specified in ASTM C 109 at intervals during construction as selected by the ENGINEER. A set of three specimens will be made for testing at seven days, 28 days, and each additional time period as appropriate.
   3. Compression tests and fabrication of specimens for epoxy grout will be performed as specified in ASTM C 579, Method B, at intervals during construction as selected by the ENGINEER. A set of three specimens will be made for testing at seven days, and each earlier time period as appropriate.
   4. The cost of all laboratory tests on grout will be borne by the OWNER, but CONTRACTOR provide assistance to the ENGINEER in obtaining specimens for testing. However, the cost of any additional tests and investigation on work performed which does not conform to the requirements of the specifications belongs to CONTRACTOR. Supply all materials necessary for fabricating the test specimens.

1.3 SUBMITTALS

A. Shop Drawings, submit for approval the following:
   1. For Grout Fill and Construction Joint Grout, copies of grout design mix and laboratory test reports for grout strength tests.

B. Reports and Certificates, submit for approval the following:
   1. For proprietary materials, submit copies of manufacturer’s certification of compliance with the specified properties for Class I, II, and III grouts.
   2. Submit certified testing lab reports for ASTM C 1107, Grade B and Grade C (as revised herein) requirements for Class I and II grouts tested at a fluid consistency for temperatures of 45, 73.4, 90°F with a pot life of 30 minutes at fluid consistency.
   3. Submit certification that materials meet specification requirements for nonproprietary materials.
   4. Submit certifications that all grouts used on the project are free of chlorides or other chemicals causing corrosion.
   5. Manufacturer's specifications and installation instructions for all proprietary materials.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Delivery of Materials: Grout materials from manufacturers shall be delivered in unopened containers and shall bear intact manufacturer's labels.

B. Storage of Materials: Grout materials shall be stored in a dry shelter and shall be protected from moisture.

PART 2 - PRODUCTS

2.1 GROUTS

A. General: Non-shrink grout shall be a prepackaged, inorganic, flowable, non-gas-liberating, non-metallic, cement-based grout requiring only the addition of water. Manufacturer's instructions shall be printed on each bag or other container in which the materials are packaged. The specific formulation for each class of non-shrink grout specified herein shall be that recommended by the manufacturer for the particular application.

B. Class I Non-Shrink Grout:
   1. Class I non-shrink grouts shall have a minimum 28 day compressive strength of 7000 psi. This grout is for precision grouting and where water tightness and non-shrink reliability in both plastic and hardened states are critical. Refer to areas of application as specified herein.
   2. Shall meet the requirements of ASTM C 1107 Grade C and B (as modified below) when tested using the amount of water required to achieve the following properties:
      a. Fluid consistency (20 to 30 seconds) in accordance with ASTM C 939
      b. At temperatures of 45, 73.4, and 95°F.
   3. The length change from placement to time of final set shall not have a shrinkage greater than the amount of expansion measured at 3 or 14 days. The expansion at 3 or 14 days shall not exceed the 28-day expansion.
   4. The non-shrink property is not based on a chemically generated gas or gypsum expansion.
   5. Fluid grout shall pass through the flow cone, with a continuous flow, one hour after mixing.
   6. Product and Manufacturer: Provide one of the following:
   7. BASF Building Systems; MasterFlow 928.
   8. Five Star Products; Five Star Fluid Grout 100.
   9. Euclid Chemical Co.; Hi Flow Grout.

D. Class III Non-Shrink Epoxy Grout:
   1. Epoxy grout shall be a pourable, non-shrink, 100 percent solids system. The epoxy grout system shall have three components: resin, hardener, and specially blended aggregate, all premeasured and prepackaged. The resin component shall not contain any non-reactive diluents. Resins containing butyl glycidyl

ether (BGE) or other highly volatile and hazardous reactive diluents are not acceptable. Variation of component ratios is not permitted, unless specifically recommended by the manufacturer. Manufacturer's instructions shall be printed on each container in which the materials are packaged. The following properties shall be attained with the minimum quantity of aggregate allowed by the manufacturer.

2. Product and Manufacturer: Provide one of the following:
   a. Euclid Chemical Co; E3 Flowable.
   b. BASF Building Systems; MasterFlow 648.
   c. Five Star Products, Inc.; DP Epoxy Grout.
   d. Or equal.
3. The vertical volume change at all times before hardening shall be between 0.0 percent shrinkage and 4.0 percent expansion when measured according to ASTM C 827 (modified for epoxy grouts by using an indicator ball with a specific gravity between 0.9 and 1.1). Alternately, epoxy grouts which maintain an effective bearing area of not less than 95 percent are acceptable.
4. The length change after hardening shall be negligible (less than 0.0006 in/in) and the coefficient of thermal expansion shall be less than 0.00003 in/in/F when tested in accordance to the requirements of ASTM C 531.
5. The compressive creep at one year shall be negligible (less than .001 in/in) when tested under a 400 psi constant load at 140°F in accordance to the requirements of ASTM C 1181.
6. The seven day compressive strength shall be a minimum of 14,000 psi when tested in accordance to the requirements of ASTM C 579
7. The grout shall be capable of maintaining at least a flowable consistency for a minimum of 30 minutes at 70°F.
8. The shear bond strength to portland cement concrete shall be greater than the shear strength of the concrete when tested in accordance to the requirements of ASTM C 882.
9. The effective bearing area shall be a minimum of 95 percent.

E. Grout Fill, Topping Grout:
   1. Grout for topping of slabs and concrete fill for built-up surfaces of tank, channel, and basin bottoms shall be composed of cement, fine aggregate, coarse aggregate, water, and admixtures proportioned and mixed as specified herein. All materials and procedures specified for normal concrete in Section 03300, Cast-In-Place Concrete, shall apply except as noted otherwise herein.
   2. Topping grout and concrete fill shall contain a minimum of 564 pounds of cement per cubic yard with a maximum water cement ratio of 0.45. Where concrete fill is thicker than 4-inches, Type “1” concrete, as specified in Section 03300, Cast-In-Place Concrete, may be used when accepted by the ENGINEER.
   3. Coarse aggregate shall be graded as follows:

U.S. STANDARD SIEVE SIZE	PERCENT BY WEIGHT PASSING
1/2-inch	100
3/8-inch	90-100
No. 4	20-55
No. 8	5-30
No. 16	0-10
No. 30	0

4. Final mix design shall be as determined by trial mix design under supervision of the approved testing laboratory.
5. Strength: Minimum compressive strength of Grout Fill at the end of 28 days shall be 4000 psi.

F. Construction Joint Grout:
1. Construction Joint Grout approximates Type "1" concrete, as specified in Section 03300, Cast-In-Place Concrete, with aggregate coarser than 1/2-inch removed. The mix is to be designed as flowable with a high mortar content. It is intended to be placed over construction joints and mixed with Type "1" concrete as specified in Section 03300, Cast-In-Place Concrete. The mix requirements are as follows:
   a. Compressive Strength: 4,500 psi minimum at 28-days.
   b. Maximum Water-Cement Ratio: 0.45 by weight.
   c. Coarse Aggregate: ASTM C33, No. 8 size.
   d. Fine Aggregate: ASTM C33, approximately 60 percent by weight of total aggregate.
   e. Air Content: 8±1 percent.
   f. Minimum Cement Content: 752 pounds per cubic yard.

G. Requirements for Grout Fill and Construction Joint Grout
1. Proportion mixes by either laboratory trial batch or field experience methods, using materials to be employed on the Project for grout required. Comply with ACI 211.1 and report to ENGINEER the following data:
   a. Complete identification of aggregate source of supply.
   b. Tests of aggregates for compliance with specified requirements.
   c. Scale weight of each aggregate.
   d. Absorbed water in each aggregate.
   e. Brand, type and composition of cement.
   f. Brand, type and amount of each admixture.
   g. Amounts of water used in trial mixes.
   h. Proportions of each material per cubic yard.
   i. Gross weight and yield per cubic yard of trial mixtures.
   j. Measured slump.
   k. Measured air content.

l. Compressive strength developed at seven days and 28 days, from not less than three test specimens cast for each seven day and 28-day test, and for each design mix.
2. Submit written reports to ENGINEER of proposed mix of grout at least 30 days prior to start of Work. Do not begin grout production until mixes have been approved by ENGINEER.
3. Laboratory Trial Batches: When laboratory trial batches are used to select grout proportions, prepare test specimens and conduct strength tests as specified in ACI 301, Section 4 - Proportioning. However, mixes need not be designed for greater than 125 percent of the specified strength, regardless of the standard deviation of the production facility.
4. Field Experience Method: When field experience methods are used to select grout proportions, establish proportions as specified in ACI 301, Section 4.
5. Admixtures: Use air-entraining admixture in all grout. Use amounts of admixtures as recommended by the manufacturer for climatic conditions prevailing at the time of placing. Adjust quantities and types of admixtures as required to maintain quality control. Do not use admixtures which have not been incorporated and tested in the accepted design mix, unless otherwise authorized in writing by ENGINEER.

2.2 CURING MATERIALS

A. Curing materials shall be as specified in Section 03300, Cast-in-Place Concrete, and as recommended by the manufacturer of prepackaged grouts.

2.3 CONSISTENCY

A. The consistency of grouts shall be that necessary to completely fill the space to be grouted for the particular application. Dry pack consistency is such that the grout is plastic and moldable but will not flow. Where "dry pack" is called for in the Contract Documents, it shall mean a grout of that consistency; the type of grout to be used shall be as specified herein for the particular application.

B. The slump for topping grout and grout fill shall be adjusted to match placement and finishing conditions, but shall not exceed 4-inches.

C. The slump for Construction Joint Grout shall be 7 ± 1-inches.

PART 3 - EXECUTION

3.1 INSPECTION

A. Examine the substrate and conditions under which grout is to be placed and notify ENGINEER, in writing, of unsatisfactory conditions. Do not proceed with the Work until unsatisfactory conditions have been corrected in a manner acceptable to ENGINEER.

3.2 INSTALLATION

A. General:
   1. Place grout as shown and in accordance with manufacturer's instructions. If manufacturer's instructions conflict with the Specifications do not proceed until ENGINEER provides clarification.
   2. Manufacturers of proprietary products shall make available upon 72 hours notification the services of a qualified, full time employee to aid in assuring proper use of the product under job conditions.
   3. Placing grout shall conform to temperature and weather limitations in Section 03300, Cast-In-Place Concrete.
   4. Grout shall be cured following manufacturer's instructions for prepackaged grout and the requirements in Section 03300, Cast-In-Place Concrete, for grout fill and topping grout.

B. Columns, Beams and Equipment Bases:
   1. Epoxy grout: After shimming equipment to proper grade, securely tighten anchor bolts. Properly form around the base plates, allowing sufficient room around the edges for placing the grout. Adequate depth between the bottom of the base plate and the top of concrete base must be provided to assure that the void is completely filled with the epoxy grout.
   2. Non-shrink, non-metallic grout: After shimming columns, beams and equipment to proper grade, securely tighten anchor bolts. Properly form around the base plates allowing sufficient room around the edges for placing the grout. Adequate depth between the bottom of the base plate and the top of concrete base must be provided to assure that the void is completely filled with the non-shrink, non-metallic grout.

C. Handrails and Railings:
   1. After posts have been properly inserted into the holes or sleeves, fill the annular space between posts and sleeve with the non-shrink, non-metallic grout. Bevel grout at juncture with post so that moisture flows away from post.

D. Construction Joints:
   1. Place a 6-inch minimum thick layer of Construction Joint Grout over the contact surface of the old concrete at the interface of horizontal construction joints as specified in Section 03251, Concrete Joints, and Section 03300, Cast-In-Place Concrete.

E. Topping Grout:
   1. All mechanical, electrical, and finish work shall be completed prior to placement of topping grout. The base slab shall be given a roughened textured surface by sandblasting or hydroblasting exposing the aggregates to ensure bonding to the base slab.
   2. The minimum thickness of grout topping shall be 1-inch.

3. The base slab shall be thoroughly cleaned and wetted prior to placing topping and fill. No topping concrete shall be placed until the slab is complete free from standing pools or ponds of water. A thin coat of neat Type II cement slurry shall be broomed into the surface of the slab and topping or fill concrete shall be placed while the slurry is still wet. The topping and fill shall be compacted by rolling or tamping, brought to established grade, and floated. Grouted fill for tank and basin bottoms where scraping mechanisms are to be installed shall be screeded by blades attached to the revolving mechanism of the equipment in accordance with the procedures outlined by the equipment manufacturer after the grout is brought to the established grade.
4. Topping grout placed on sloping slabs shall proceed uniformly from the bottom of the slab to the top, for the full width of the placement.
5. The surface shall be tested with a straight edge to detect high and low spots which shall be immediately eliminated. When the topping has hardened sufficiently, it shall be steel troweled to a smooth surface free from pinholes and other imperfections. An approved type of mechanical trowel may be used as an assist in this operation, but the last pass over the surface shall be by hand-troweling. During finishing, no water, dry cement or mixture of dry cement and sand shall be applied to the surface.
6. Cure and protect the grout topping as specified in Section 03300, Cast-In-Place Concrete.

F. Grout Fill
1. All mechanical, electrical, and finish work shall be completed prior to placement of grout fill. Grout fill shall be mixed, placed, and finished as required in Section 03300, Cast-In-Place Concrete.
2. The minimum thickness of grout fill shall be 1-inch. Where the finished surface of grout fill is to form an intersecting angle of less than 45 degrees with the concrete surface it is to be placed against, a key shall be formed in the concrete surface at the intersection point. The key shall be a minimum of 3-1/2-inches wide by 1-1/2-inches deep.
3. The surface shall be tested with a straight edge to verify that the surface slopes uniformly to drain and to detect high and low spots which shall be immediately eliminated. When the grout fill has hardened sufficiently, it shall be steel troweled to a smooth surface free from pinholes and other imperfections. During finishing, no water, dry cement or mixture of dry cement and sand shall be applied to the surface.

+ + END OF SECTION + +

SECTION 05051

ANCHOR BOLTS, TOGGLE BOLTS AND CONCRETE INSERTS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals as shown on the Drawings, specified, and required to furnish and install anchor bolts, toggle bolts and concrete inserts.

B. This Section includes all anchor bolts, toggles and inserts required for the Work, but not specified under other Sections.

C. The types of Work using the anchor bolts, toggles and inserts include, but are not limited to the following:
   1. Baffles, weirs and troughs.
   2. Sprockets and conveyors.
   3. Rails.
   4. Sluice and slide gates.
   5. Hangers and brackets.
   6. Equipment.
   7. Piping.
   8. Tanks.
   9. Screens.
   10. Grating and floor plate.
   11. Electrical, Plumbing and HVAC Work.
   12. Metal, wood and plastic fabrications.
   13. Partitions and ceilings.
   14. Shelf angles and masonry lintels.
   15. Structural members and accessories.

1.2 QUALITY ASSURANCE

A. Reference Standards: Comply with the applicable provisions and recommendations of the following, except as otherwise shown and specified.
   1. ASTM A 36, Specification for Carbon Structural Steel.
   2. ASTM A 123, Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   3. ASTM A 153, Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

4. ASTM A 307, Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
5. ASTM A 484, Specification for General Requirements for Stainless and Heat-Resisting Steel Bars, Billets and Forgings.
6. ASTM A 525, Specification for General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process.
7. ASTM A 536, Specification for Ductile Iron Castings.
8. ASTM A 570, Specification for Steel, Sheet and Strip, Carbon, Hot-Rolled, Structural Quality.
9. ASTM B 633, Specification for Electrodeposited Coatings of Zinc on Iron and Steel.
10 ASTM F 593, Stainless Steel Bolts; Hex Cap Screws, and Studs.
11. Federal Specification FF-S-325 for Concrete Expansion Anchors.
12. Federal Specifications WW-H-171E for Malleable Iron.
13. ICBO, International Conference of Building Officials.
14. Phoenix Building Code.

B. Inserts shall be ICBO, UL or FM approved.

C. Toggle Bolts: Federal Specification FF-B-588C, Type I, Class A, Style 1.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
1. Setting drawings and templates for location and installation of anchorage devices.
2. Copies of manufacturer's specifications, load tables, dimension diagrams and installation instructions for the devices.
3. Copies of ICBO, UL or FM Reports certifying load carrying capacities and installation requirements for the anchorage devices.
4. Comply with the requirements of Section 01332, Shop Drawing Procedures.

B. Samples: Submit for approval the following:
1. Representative samples of anchor bolts, toggle bolts and concrete inserts as may be requested by ENGINEER. Review will be for type and finish only. Compliance with all other requirements is exclusive responsibility of CONTRACTOR.

PART 2 - PRODUCTS

2.1 DESIGN CRITERIA

A. When the size, length or load carrying capacity of an anchor bolt, toggle bolt, or concrete insert is not shown on the Drawings, provide the following:

1. For anchor bolts (cast-in-place), provide the size, length and capacity required to carry the design load based on the values and requirements given in the Phoenix Building Code for concrete.
2. For concrete anchors (adhesive types) and concrete inserts, provide the size, length, type, and capacity required to carry the design load based on the values and requirements given in the ICBO Evaluation Report, or similar certifications by UL or FM, for the anchor to be used. Alternately the capacity may be based on independent testing lab capacities for tension and shear strength using a minimum safety factor of four. Consideration of reduced capacity due to spacing and edge distance shall be made.

B. Determine design loads as follows:
1. For equipment anchors, use the design load recommended by the equipment manufacturer and approved by ENGINEER.
2. For pipe hangers and supports, use one half of the total weight of: pipe, fittings, and water contained in pipe, plus the full weight of valves and accessories located between the hanger or support in question.
3. Allowances for vibration are included in the safety factor specified above.
4. Concrete anchors shall develop ultimate shear and pull-out loads of not less than the following values in 4,000 psi concrete:

Bolt Diameter (Inches)	Min. Shear (Pounds)	Min. Pull-Out Load (Pounds)
1/2	5,000	7,600
5/8	8,000	12,000
3/4	11,500	17,000
7/8	15,700	20,400
1	20,500	28,400

2.2 APPLICATION

A. Where a concrete anchor is shown on the Drawings, install either an adhesive anchor or anchor bolt. In masonry, where a concrete anchor is shown on the Drawings, only anchor bolts and adhesive anchors shall be used. Comply with the requirements of Section 06100, Rough Carpentry, Section 06611, Fiberglass Reinforced Plastic Gratings, Handrails and Railings, and Sections 06612 and 06613, Fiberglass Reinforced Plastic Troughs, Weir Plates, and Baffles (Wastewater and Water Treatment).

B. Anchor Bolts (cast-in-place):
1. Shall be used where indicated and may be used where concrete anchors are indicated.
2. Where an anchor bolt is indicated, only a cast-in-place anchor bolt shall be used, unless another anchor type is accepted by the ENGINEER.
3. Provide anchor bolts as shown on the Drawings or as required to secure structural steel to concrete or masonry.

C. Adhesive Anchors:
   1. Use wherever concrete anchors are shown on the Drawings.
   2. Use where subject to vibration or where buried or submerged.
   3. Use for pipe supports.
   4. Use in concrete and masonry.
   5. Shall not be used in ceilings.
   6. Shall not be used for pipe hangers.

D. Concrete Inserts:
   1. Use only where indicated on the Drawings.
   2. Use for pipe hangers and supports for the pipe size and loading recommended by the insert manufacturer.

E. Toggle Bolts:
   1. Use for fastening brackets and other elements onto masonry units.

2.3 MATERIALS

A. Anchor Bolts:
   1. Provide carbon steel bolts complying with ASTM A 307, headed or non-headed type, unless otherwise indicated.
   2. Provide stainless steel complying with ASTM F 593, AISI Type 316 headed or non-headed type with nitronic 60 stainless steel nuts and locknuts, unless otherwise indicated.
   3. In buried or submerged locations, provide Type 2205 duplex stainless steel bolts complete with washers complying with ASTM F 593 with Type 2205 duplex stainless steel nuts and locknuts.
   4. For equipment, provide anchor bolts, which meet the equipment manufacturer's recommendations for size, material, and strength.
   5. Provide anchor bolts as shown on the Drawings or as required to secure structural steel to concrete or masonry.
   6. Locate and accurately set the anchor bolts using templates or other devices as required.
   7. Protect threads and shank from damage during installation of equipment and structural steel.
   8. Comply with manufacturer’s required embedment length and necessary anchor bolt projection.

B. Adhesive Anchors:
   1. Provide stainless steel adhesive anchors complying with ASTM F 593, AISI Type 316 with nitronic 60 stainless steel nuts and locknuts.
   2. In buried or submerged locations, provide Type 2205 duplex stainless steel bolts complete with washers complying with ASTM F 593 with Type 2205 duplex stainless steel nuts and locknuts.
   3. Anchors shall be of the size required for the concrete strength specified.

4. Adhesive anchors shall consist of threaded rods or bolts anchored with an adhesive system into hardened concrete or grout-filled masonry. The adhesive system shall use a two-component adhesive mix and shall be injected with a static mixing nozzle following manufacturer's instructions. The embedment depth of the rod/bolt shall provide a minimum allowable bond strength that is equal to the allowable tensile capacity of the rod/bolt, unless noted otherwise on the Drawings.
5. Product and Manufacturer: Provide one of the following:
   a. Epcon System Ceramic 6, as manufactured by ITW Ramset/Redhead.
   b. HIT HY-150 Injection Adhesive Anchor System, as manufactured by Hilti.
   c. Powerfast, as manufactured by Powers/Rawl.
   d. Or equal.

C. Sleeve Expansion Anchors for Installation in Concrete Masonry:
1. Provide carbon steel anchors complete with nuts and washers, zinc plated, in accordance with ASTM B 633, and meet the requirements of Federal Specification FF-S-325, Group II, Type 4, Class 1 for expansion anchors.
2. Product and Manufacturer: Provide anchors by one of the following:
   a. Sleeve Anchors, as manufactured by Hilti Fastening Systems, Incorporated.
   b. Dynabolt Sleeve, as manufactured by ITW Ramset/Red Head, Incorporated.
   c. Or equal.

D. Concrete Inserts:
1. For piping, grating, floor plate and masonry lintels, provide malleable iron inserts. Comply with Federal Specification WW-H-171E (Type 18). Provide those recommended by the manufacturer for the required loading.
2. Finish shall be black.
3. Product and Manufacturer: Provide inserts by one of the following:
   a. Figure 282, as manufactured by ITT Grinnell.
   b. No. 380, as manufactured by Hohmann and Barnard, Incorporated.
   c. Or equal.

E. Toggle Bolts:
1. Provide spring-wing toggle bolts, with two-piece wings.
2. Provide carbon steel bolts with zinc coating in accordance with Federal Specification FF-S-325.
3. Product and Manufacturer: Provide toggle bolts by one of the following:
   a. The Rawlplug Company, Incorporated.
   b. Haydon Bolts, Incorporated.
   c. Or equal.

F. Powder activated fasteners and other types of bolts and fasteners not specified herein shall not be used, unless approved by ENGINEER.

G. Expansion anchors will not be allowed.

PART 3 - EXECUTION

3.1 INSPECTION

A. Examine areas and conditions under which anchor bolts, toggle bolts and concrete insert Work is to be installed, and notify ENGINEER, in writing, of conditions detrimental to proper and timely completion of Work. Do not proceed with Work until unsatisfactory conditions have been corrected in a manner acceptable to ENGINEER.

3.2 INSTALLATION

A. Assure that embedded items are protected from damage and are not filled in with concrete.

B. Use concrete inserts for pipe hangers and supports for the pipe size and loading recommended by the insert manufacturer.

C. Use toggle bolts for fastening brackets and other elements onto masonry units.

D. For the adhesive anchors and adhesive material, comply with the manufacturer's installation instructions on the hole diameter and depth required to fully develop the tensile strength of the adhesive anchor or reinforcing bar. Properly clean out the hole utilizing a wire brush and compressed air to remove all loose material from the hole, prior to installing adhesive capsules or material.

3.3 CLEANING

A. After embedding concrete is placed, remove protection and clean bolts and inserts.

3.4 FIELD QUALITY CONTROL

A. Employ the services of a testing laboratory to perform field quality testing of installed anchors. Field engineer is to determine the level of testing which is required for the various types of adhesive anchors and anchor bolts. A minimum of ten percent of the adhesive anchors and reinforcing bars are to be tested to 50 percent of the ultimate tensile capacity of the adhesive anchor or reinforcing bar.

B. Responsibility for the failure of any adhesive anchors or reinforcing bars will belong to the CONTRACTOR. Should any adhesive anchors or reinforcing bars fail, all costs involved in testing the remaining 90 percent belongs to the CONTRACTOR.

C. Correct improper workmanship, remove and replace, or correct as directed by the ENGINEER, all adhesive anchors or bars found unacceptable or deficient, at no additional cost to the OWNER.

D. Pay for all corrections and subsequent tests required to confirm the integrity of the adhesive anchor or bar.

E. The independent testing and inspection agency shall complete a report on each area. The report should summarize the observations made by the inspector and be submitted to ENGINEER.

F. Provide access for the testing agency to places where Work is being produced so that required inspection and testing can be accomplished.

+ + END OF SECTION + +

SECTION 05501

MISCELLANEOUS METAL FABRICATIONS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish miscellaneous metal fabrications, including surface preparation and shop priming.

B. The extent of miscellaneous metal fabrications Work is shown on the Drawings and includes items fabricated from iron, steel and aluminum shapes, plates, bars, castings and extrusions, which are not a part of the structural steel or other metal systems covered by other Sections of these Specifications.

C. The types of miscellaneous metal items include, but are not limited to the following:
   1. Aluminum ladders.
   2. Aluminum ladder safety cages.
   3. Loose steel lintels.
   4. Shelf angles.
   5. Extruded aluminum stair nosings.
   6. Wheel guards.
   7. Fall prevention system.

1.2 QUALITY ASSURANCE

A. Reference Standards: Comply with the applicable provisions and recommendations of the following, except as otherwise shown and specified:
   1. ASTM A36, Specification for Carbon Structural Steel.
   2. ASTM A153, Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   3. ASTM A240, Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet and Strip for Pressure Vessels.
   4. ASTM A320, Specification for Alloy Steel Bolting Material for Low Temperature Service.
   5. ASTM B209, Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
   6. ASTM B211, Specification for Aluminum and Aluminum-Alloy Bars, Rods and Wire.
   7. ASTM B221, Specification for Aluminum-Alloy Extruded Bars, Rods, Wire, Shapes and Tubes.
   8. ANSI A14.3, Safety Requirements for Fixed Ladders.

9. AWS D1.1, Structural Welding Code.
10. NAAMM, Metal Finishes Manual.
11. OSHA.
12. Phoenix Building Code.

B. Field Measurements:
   1. Take field measurements where required prior to preparation of Shop Drawings and fabrication to ensure proper fitting of the Work.

C. Shop Assembly:
   1. Preassemble items in the shop to the greatest extent possible, so as to minimize field splicing and assembly of units at the project site. Disassemble units only to the extent necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation.

1.3 SUBMITTALS

A. Samples: Submit for approval the following:
   1. Sets of representative samples of materials including nosings, rungs and other finished products as may be requested by ENGINEER. ENGINEER'S review will be for color, texture, style, and finish only. Compliance with all other requirements is exclusive responsibility of CONTRACTOR.
   2. Refer to and comply with the requirements of Section 01333, Samples.

B. Shop Drawings: Submit for approval the following:
   1. Fabrication and erection details of all assemblies of miscellaneous metal Work. Include plans, elevations, and details of sections and connections. Show anchorage and accessory items. Include setting drawings and templates for location and installation of miscellaneous metal items and anchorage devices.
   2. Copies of manufacturer's specifications, load tables, dimension diagrams, anchor details, and installation instructions for products to be used in miscellaneous metal Work.
   3. Refer to and comply with the requirements of Section 01330, Submittals and Section 16050, General Provisions.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Steel Plates, Shapes and Bars: ASTM A 36.

B. Aluminum:
   1. Alloy and Temper: Provide alloy and temper as shown on the Drawings or specified, or as otherwise recommended by the aluminum producer or finisher.
   2. Extruded Shapes and Tubes: ASTM B 221.

3. Plate and Sheet: ASTM B 209.
4. Bars, Rods and Wire: ASTM B 211.

C. Stainless Steel Plates and Sheets: ASTM A240, Type 304L or Type 316 stainless steel.
1. Submerged or intermittently submerged: Type 316 stainless steel.
2. Non-submerged: Type 304L stainless steel.

D. Stainless Steel Fasteners and Fittings: ASTM A 320.

E. Zinc Coated Hardware: ASTM A 153.

F. Surface Preparation and Shop Priming: Refer to Section 09900, Painting. All steel shall be primed in the shop. Surface preparation and shop priming requirements are included herein, but are specified in Section 09900.

2.2 MISCELLANEOUS METAL ITEMS

A. Aluminum Ladders:
1. Fabricate ladders for the locations shown on the Drawings, with dimensions, spacings, details and anchorages as shown on the Drawings, and specified. Comply with the requirements of ANSI A14.3, except as otherwise shown on the Drawings or specified.
a. Unless otherwise shown on the Drawings, provide 1/2-inch by 2-1/2-inch continuous extruded flat bar side rails, spaced 18-inches apart, minimum.
b. Provide extruded square rungs, spaced 12-inches on centers, maximum, with non-slip surface on the top of each rung. Adhesive strips for non-slip surfaces will not be allowed.
2. Fit rungs in centerline of side rails, plug weld and grind smooth on outer rail faces.
3. Support each ladder at top and bottom and at intermediate points spaced not more than five feet on centers. Use welded or bolted brackets, designed for adequate support and anchorage, and to hold the ladder clear of the wall surface with a minimum of 7-inches clearance from wall to centerline of rungs. Unless otherwise shown on the Drawings or approved by the Engineer, extend rails 42-inches above top rung, and return rails to wall or structure, unless other secure handholds are provided. If the adjacent structure does not extend above the top rung, goose-neck the extended rails back to the structure to provide secure ladder access.
4. Use extruded aluminum conforming to alloy and temper 6061-T6.

B. Aluminum Ladder Safety Cages:
1. Fabricate ladder safety cages from extruded flat bars, assembled by welding or riveting. Unless otherwise shown on the Drawings, provide 1/2-inch by 3-inch top, bottom and intermediate hoops spaced not more than five feet on centers;

and 3/8-inch by 2-inch vertical bars, secured to each hoop. Space vertical bars approximately 9- inches on centers. Fasten assembled safety cage to ladder rails and adjacent construction as shown on the Drawings. Grind all welds, sharp edges and projections smooth.

2. Comply with the requirements of ANSI A14.3.
3. Use extruded aluminum conforming to alloy and temper 6061-T6.

C. Loose Steel Lintels:
   1. Provide loose structural steel lintels for openings and recesses in masonry walls and partitions as shown on the Drawings. Weld adjoining members together to form a single unit where shown on the Drawings. Provide not less than 8-inches bearing at each side of openings, unless otherwise shown on the Drawings.
      a. Galvanize loose steel lintels to be installed in exterior walls.

D. Shelf Angles:
   1. Provide structural steel shelf angles of sizes shown on the Drawings for attachment to concrete or masonry construction. Provide slotted holes to receive 3/4-inch bolts, spaced not more than 6-inches from ends and not more than 24-inches on centers, unless otherwise shown on the Drawings.

Galvanize shelf angles shall be installed on exterior construction.

E. Extruded Aluminum Stair Nosings:
   1. Fabricate of sizes and configurations as shown on the Drawings.
      a. Unless otherwise shown on the Drawings, provide ribbed abrasive filled type, using black abrasive filler.
   2. Provide anchors for embedding in concrete, either integral or applied to treads, as standard with the manufacturer.
   3. Product and Manufacturer: Provide stair nosings by one of the following:
      a. American Abrasive Metals Company.
      b. Wooster Products Incorporated.
      c. Or equal.

F. Wheel Guards:
   1. Provide wheel guards of the bolted type, 3/4-inch thick minimum of hollow core gray iron casting, and of size and shape as shown on the Drawings. Provide holes for countersunk anchor bolts and grouting.
   2. Anchor wheel guards to concrete or masonry construction in compliance with the manufacturer's instructions. Fill cores solidly, using grout as specified in Section 03600, Grout.
   3. Wheel guards of the armored concrete type will not be permitted.
   4. Product and Manufacturer: Provide wheel guards by one of the following:
      a. Neenah Foundry Company.
      b. Flockhart Foundry Company.
      c. Or equal.

G. Fall Prevention System: All ladders shall be provided with a fall prevention system. The system shall meet OSHA standards.
   1. The system shall consist of a rail permanently attached to the ladder to which a harness belt is attached. The rail shall be notched and constructed of aluminum. Ladder attachments shall be provided as required by the manufacturer. A removable extension section shall be provided at the top of the ladder.
   2. Product and Manufacturer: Provide one of the following:
      a. Saf-T-Climb by Norton Company.
      b. Or equal.

H. Bollards: Provide 8-inch diameter, Schedule 40 black steel pipe, 4-feet-0-inches above grade, 4-feet-0-inches below grade. Fill with concrete and mound top. Bollards shall be primed in the shop. Surface preparation and painting shall conform to the requirements of Section 09900, Painting.

I. Miscellaneous Framing and Supports:
   1. Provide miscellaneous metal framing and supports, which are not a part of the structural steel framework and are required to complete the Work.
   2. Fabricate miscellaneous units to the sizes, shapes and profiles shown on the Drawings or, if not shown on the Drawings, of the required dimensions to receive adjacent grating, plates, tanks, doors, or other work to be retained by the framing. Except as otherwise shown on the Drawings, fabricate from structural shapes, plates, and bars, of all welded construction using mitered corners, welded brackets and splice plates and a minimum number of joints for field connection. Cut, drill and tap units to receive hardware and similar items to be anchored to the Work.
   3. Equip units with integrally welded anchors for casting into concrete or building into masonry. Furnish inserts if units must be installed after concrete is placed.
      a. Except as otherwise shown on the Drawings, space anchors, 24-inches on centers, and provide units the equivalent of 1-1/4 by 1/4 by 8-inch strips.
      b. Galvanize exterior miscellaneous frames and supports.
      c. Galvanize miscellaneous frames and supports where indicated.

J. Fasteners and Fittings: Provide Type 316 stainless steel, for all aluminum fabrications, and zinc coated hardware for all galvanized fabrications, unless otherwise shown on the Drawings or specified.

K. Surface Preparation and Shop Priming: All miscellaneous metal fabrications shall be primed in the shop. Surface preparation and shop priming requirements are included herein, but are specified in Section 09900, Painting.

L. Aluminum Finish: Provide an Architectural Class 1 anodized finish, AA-M32C22-A41, as specified in NAAMM Manual.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Set miscellaneous metal fabrications accurately in location, alignment and elevation, plumb, level, true and free of rack, measured from established lines and levels. Brace temporarily or anchor temporarily in formwork where fabrications are to be built into concrete, masonry or similar construction.

B. Anchor securely as shown on the Drawings or as required for the intended use, using concealed anchors wherever possible.

C. Fit exposed connections accurately together to form tight hairline joints. Weld steel connections, which are not to be left as exposed joints, but cannot be shop welded because of shipping size limitations. Grind steel joints smooth and touch up shop paint coat. Do not weld, cut or abrade the surfaces of exterior units, which have been hot-dip galvanized after fabrication, and are intended for bolted or screwed field connections.

D. Protection of Aluminum from Dissimilar Materials:
   1. Coat all surfaces of aluminum in contact with dissimilar materials, such as concrete, masonry and steel conforming to the requirements of Section 09900, Painting.

+ + END OF SECTION + +

SECTION 07920

CAULKING AND SEALANTS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, tools, equipment and incidentals as shown on the Drawings, specified and required to furnish and install caulking and sealants.
   2. Extent of each type of caulking and sealant is shown on the Drawings and includes the following:
      a. All joints between concrete members and masonry.
      b. All concrete to concrete joints.
      c. All metal to metal joints.
      d. All joints between masonry and metal.
      e. All expansion joints in masonry and concrete.
      f. All control joints.
      g. All joints between reglets and flashing.
      h. All sound-sealed and air-sealed joints.
      i. As an exposed-to-view finish on the exposed face of all fire-rated sealants.
      j. On both sides of all terminations of all construction systems, specified to receive caulking and sealants, where construction system remains exposed-to-view in the finished Work.
      k. All isolation joints between equipment and other items.
      l. All joints where construction systems are discontinuous or inherently non-watertight.
      m. All locations whether or not shown on the Drawings, required to render the building watertight, except where a construction system is specified or shown as not relying upon the use of sealants in order to achieve weather and watertightness.
   3. Types of products required include the following:
      a. Two-component, urethane based, non-sag, elastomeric sealant.
      b. Two-component, urethane based, self-leveling, elastomeric sealant.
      c. Polyethylene backer rods.
      d. Miscellaneous materials and accessories.

B. Coordination:
   1. Review installation procedures under other Sections and coordinate the installation of items that must be installed with the caulking and sealants.
   2. Coordinate the final selection of caulking and sealants to be compatible with all calking and sealant substrates specified.

1.2 QUALITY ASSURANCE

A. Installer Qualifications: Engage a single installer regularly engaged in caulking and sealant installation and with successful experience in the application of the types of materials required, and who agrees to employ only tradesmen with specific skill and successful experience in this type of Work.

B. Job Mock-ups:
   1. Prior to the installation of caulking and sealant Work, but after ENGINEER'S approval of samples, install sample of each type of caulking and sealant in areas selected by ENGINEER to show a representative installation of the caulking and sealants. Obtain ENGINEER'S acceptance of visual qualities of the mock-ups before start of caulking and sealant Work. Retain and protect mock-ups during construction as a standard for judging completed caulking and sealant Work. Do not alter mock-ups.
   2. Caulking and sealant Work that does not meet the standard approved on the sample areas shall be stopped, removed and replaced with new material.

C. Source Quality Control: Obtain materials from only manufacturers who will, if required:
   1. Send a qualified technical representative to the site, for the purpose of advising installer of proper procedures and precautions for the use of the materials.
   2. Test caulking and sealants for compatibility with the substrates specified for conformance to FS-TT-S-0027, and recommend remedial procedures as required.

D. Reference Standards: Comply with applicable provisions and recommendations of the following, except as otherwise shown or specified.
   1. ASTM C 510, Test Method for Staining and Color Change of Single- or Multicomponent Joint Sealants.
   2. ASTM C 661, Test Method for Identation Hardness of Elastomeric-Type Sealants by Means of a Durometer.
   3. ASTM C 793, Test Method for Effects of Accelerated Weathering on Elastomeric Joint Sealants.
   4. ASTM C 794, Test Method for Adhesion-in-Peel of Elastomeric Joint Sealants.
   5. Federal Specification, FS TT-S-00227, Sealing Compound: Elastomeric Type, Multi-component for Caulking, Sealing, and Glazing in Buildings and Other Structures.

E. Compatibility: Before purchase of each specified sealant, investigate its compatibility with the joint surfaces, joint fillers and other materials in the joint system. Provide only materials (manufacturer's recommended variation of the specified materials) which are known to be fully compatible with the actual installation condition, as verified by manufacturer's published data or certification and as shown on approved Shop Drawings.

1.3 SUBMITTALS

A. Samples: Submit for approval the following:
   1. Each type of actual cured material samples of each caulking and sealant specified, 3-inches long, in each of the manufacturer's standard colors.
   2. Each size and type of sealant backer rod, 3-inches long, as recommended by the caulking and sealant manufacturer.
   3. Bond breaker tape as recommended by the manufacturer.
   4. Samples will be reviewed by ENGINEER for color and texture only. Compliance with other requirements is the responsibility of CONTRACTOR.
   5. Refer to and comply with the requirements of Section 01333, Samples.

B. Shop Drawings: Submit for approval the following:
   1. Copies of manufacturer's specifications, recommendations and installation instructions for each type of sealant, caulking compound and associated miscellaneous material required. Include manufacturer's published data, indicating that each material complies with the requirements and is intended for the applications shown.
   2. Pre-Installation Meeting report as specified in Paragraph 1.5.A., below.

C. Test Reports: Submit for approval the following:
   1. Compatibility tests for substrates, based on adhesion-in-peel standard test procedures and FS TT-S-0027.
   2. Certified laboratory test reports indicating conformance with the requirements.

D. Guarantee: Submit for approval the following:
   1. Copies of written guarantee agreeing to repair or replace sealants which fail to perform as specified. Refer to paragraph 1.6.A of this Section.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Delivery of Materials:
   1. Deliver materials in caulking and sealant manufacturer's original unopened, undamaged containers, indicating compliance with approved Shop Drawings and approved Sample color selections.
   2. Include the following information on the label:
      a. Name of material and supplier.
      b. Formula or specification number, lot number, color and date of manufacture.
      c. Mixing instructions, shelf life and curing time, when applicable.
   3. Failure to comply with these requirements shall be sufficient cause for rejection of the material in question, by ENGINEER. Immediately remove rejected materials from the site and do not offer them again for approval by ENGINEER. Supply new material conforming to the specified requirements, at no additional expense to OWNER.

B. Storage and Handling of Materials:
   1. Store materials so as to preclude the inclusion of foreign materials.
   2. Do not store or expose materials to temperature above 90°F or store in direct sunshine.
   3. Do not use materials which are outdated as indicated by shelf life.
   4. Store sealant tape in a manner which will not deform the tape.
   5. In cool or cold weather, store containers where temperature approximates 75°F for 16 hours before using.
   6. When high temperatures prevail, store mixed sealants in a cool place.
   7. Refer to and comply with the requirements of Section 01661, Storage of Materials and Equipment.
   8. Handle materials carefully to prevent inclusion of foreign materials.
   9. Do not open containers or mix components until necessary preparatory Work and priming has been completed.

1.5 JOB CONDITIONS

A. Pre-Installation Meeting:
   1. Prior to the installation of the caulking and sealants and associated Work, schedule and meet at the job site with; the calking and sealant installer, the calking and sealant manufacturer's technical representative, other trades involved in coordination with the caulking and sealant Work, the ENGINEER, and the OWNER. Record the discussions of the Pre-Installation Meeting and the decisions and agreements (or disagreements) and furnish a copy of the record to each party attending. Review foreseeable methods and procedures related to the caulking and sealant Work, including but not necessarily limited to the following:
      a. Review project requirements, including Drawings, Specifications and other Contract Documents.
      b. Review required submittals, both completed and yet to be completed.
      c. Review status of substrate and similar considerations.
      d. Review each major caulking and sealant application required.
      e. Review availability of materials, tradesmen, equipment and facilities needed to make progress and avoid delays.
   2. Reconvene the meeting at the earliest opportunity if additional information must be developed in order to conclude the subjects under consideration.

B. Environmental Conditions:
   1. Do not proceed with installation of caulking and sealants under adverse weather conditions, or when temperatures are below or above manufacturer's recommended limitations for installation.
   2. Proceed with the Work only when forecasted weather conditions are favorable for proper cure and development of high early bond strength.
   3. Wherever joint width is affected by ambient temperature variations, install elastomeric sealants only when temperatures are in the lower third of manufacturer's recommended installation temperature range, so that sealant will

not be subjected to excessive elongation and bond stress at subsequent low temperatures.

4. When high temperatures prevail avoid mixing sealants in direct sunlight.

C. Protection: Do not allow caulking and sealants to overflow or spill onto adjoining surfaces, or to migrate into the voids of adjoining surfaces including rough textured materials. Use masking tape or other precautionary devices to prevent staining of adjoining surfaces, by either the primer/sealer or the caulking and sealant materials.

1.6 GUARANTEE

A. Provide a written guarantee agreeing to repair or replace sealants which fail to perform as air-tight and watertight joints; or fail in joint adhesion, cohesion, abrasion resistance, weather resistance, extrusion resistance, migration resistance, stain resistance, or general durability; or appear to deteriorate in any other manner not clearly specified by submitted manufacturer's data, as an inherent quality of the material for the exposure indicated. Provide guarantee signed by installer and CONTRACTOR. Provide guarantee period of two years from Final Completion. Refer to paragraph 1.3.D.1 of this Section.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Exterior and Interior Horizontal and Vertical Joints; submerged and intermittently submerged:
   1. Two-Component Polysulfide Sealant:
      a. Polysulfide-based, 2-part elastomeric sealant complying with the following:
         1) Thiokol's Building Trade Performance Specifications: Type II Class A (non-sag).
         2) Adhesion-in-Peel, FS TT-S-00227E and ASTM C 794 (minimum 5 lbs.): Glass, minimum 21 lbs./linear inch; Aluminum, minimum 18 lbs/ linear inch; Concrete, minimum 21 lbs/linear inch.
         3) Hardness (Standard Conditions), ASTM C 661: 15 to 50 (Shore A).
         4) Stain and Color Change, FS TT-S-00227E and ASTM C 510: No discoloration or stain.
         5) Accelerated Aging, ASTM C 793: No change in sealant characteristics after 250 hours in weatherometer.
         6) Rheological Vertical Displacement at 120°F, FS TT-S-00227E: No sag.
      b. Product and Manufacturer: Provide one of the following:
         1) Sonnolastic Two-Part by Sonneborn Building Products, Division of Chemrex, Inc.
         2) Lasto-Meric by Tremco.
         3) Or equal.

B. Exterior and Interior Vertical Joints; non submerged:
   1. Two-Component Urethane Sealant:
      a. Urethane-based, 2-part elastomeric sealant complying with the following:
         1) FS TT-S-00227E: Type II (non-sag) Class A.
         2) Adhesion-in-Peel, FS TT-S-00227E and ASTM C 794: (Minimum 5 lbs/linear inch with no adhesion failure): 28 lbs.
         3) Hardness (Standard Conditions), ASTM C 661: 15 to 50 (Shore A).
         4) Stain and color change, FS TT-S-00227E and ASTM C 510: No discoloration or stain.
         5) Accelerated Aging, ASTM C 793: No change in sealant characteristics after 250 hours in weatherometer.
         6) Rheological Vertical Displacement at 120°F, FS TT-S-00227E: No sag.
      b. Product and Manufacturer: Provide one of the following:
         1) Sonolastic NP 2 by Sonneborn Building Products, Division of Chemrex, Inc.
         2) Dymeric by Tremco.
         3) Or equal.

C. Exterior and Interior Horizontal Joints; non submerged:
   1. Two-Component Polyurethane Sealant:
      a. Polyurethane-based, 2-part elastomeric sealant complying with the following:
         1) FS TT-S-00227E, Type I (self-leveling) Class A.
         2) Water Immersion Bond, FS TT-S-00227E: Elongation of 25 percent with no adhesive failure.
         3) Hardness (Standard Conditions), ASTM C 661: 35 to 45.
         4) Stain and Color Change, FS TT-S-00227E and ASTM C 510: No discoloration or stain.
         5) Accelerated Aging, ASTM C 793: No change in sealant characteristics after 250 hours in weatherometer.
      b. Product and Manufacturer: Provide one of the following:
         1) SL_2 Sealant by Sonneborn Building Products, Division of Chemrex, Inc.
         2) THC/900 by Tremco.
         3) Or equal.

D. Provide colors selected by ENGINEER from caulking and sealant manufacturer's standard and custom color charts. "Or equal" manufacturers shall provide the same generic products and colors as available from manufacturers specified.

E. Miscellaneous Materials:
   1. Joint Cleaner: As recommended by the caulking and sealant manufacturer.
   2. Joint Primer and Sealer: As recommended by the caulking and sealant manufacturer.

3. Bond Breaker Type: Polyethylene tape or other plastic tape as recommended by the caulking and sealant manufacturer, to be applied to sealant-contact surfaces where bond to the substrate or joint filler must be avoided for proper performance of caulking and sealant. Provide self-adhesive tape, wherever applicable.
4. Sealant Backer Rod: Compressible rod stock polyethylene foam, polyethylene jacketed polyurethane foam, butyl rubber foam, neoprene foam or other flexible, permanent, durable nonabsorptive material as recommended for compatibility with caulking and sealant by the caulking and sealant manufacturer. Provide size and shape of rod which will control the joint depth for sealant placement, break bond of sealant at bottom of joint, form optimum shape of sealant bead on back side, and provide a highly compressible backer to minimize the possibility of sealant extrusion when joint is compressed.
5. Low Temperature Catalyst: As recommended by the calking and sealant manufacturer.

2.2 MIXING

A. Comply with sealant manufacturer's written instructions for mixing two-component sealants.

B. Thoroughly mix components before use.

C. Add entire contents of activator can to base container. Do not mix partial units.

D. Mix contents for a minimum of five minutes or as recommended by the sealant manufacturer, until color and consistency are uniform.

PART 3 - EXECUTION

3.1 INSPECTION

A. Examine joint surfaces, substrates, backing, and anchorage of units forming sealant rabbet, and the conditions under which the caulking and sealant Work is to be performed, and notify ENGINEER, in writing, of any conditions detrimental to the proper and timely completion of the Work and performance of the sealants. Do not proceed with the calking and sealant Work until unsatisfactory conditions have been corrected in a manner acceptable to ENGINEER.

3.2 JOINT SURFACE PREPARATION

A. Clean joint surfaces immediately before installation of sealant compound. Remove dirt, weakly adhering coatings, moisture and other substances which would interfere with bonds of sealant compound as recommended by sealant manufacturer's written instructions as shown on approved Shop Drawings.

B. Etch concrete and masonry joint surfaces to remove excess alkalinity, unless sealant manufacturer's written instructions, as shown on approved Shop Drawings, indicate that alkalinity does not interfere with sealant bond and performance.
   1. Etch with five percent solution of muriatic acid.
   2. Neutralize with dilute ammonia solution.
   3. Rinse thoroughly with water and allow to dry before sealant installation.

C. If necessary, clean porous materials such as concrete and masonry by grinding, sand blasting or mechanical abrading. Blow out joints with oil-free compressed air, or by vacuuming joints prior to application of primer or sealant.

D. Roughen joint surfaces on vitreous coated and similar non-porous materials, wherever sealant manufacturer's data indicates lower bond strength than for porous surfaces. Rub with fine abrasive cloth or steel wool to produce a dull sheen.

3.3 INSTALLATION

A. Comply with sealant manufacturer's written instructions, except where more stringent requirements are shown on the Drawings or specified and except where manufacturer's technical representative directs otherwise; but only as approved by ENGINEER.

B. Prime or seal the joint surfaces as shown on approved Shop Drawings. Do not allow primer or sealer to spill or migrate onto adjoining surfaces. Allow primer to dry prior to application of sealants.

C. Apply masking tape before installation of primer, in continuous strips in alignment with the joint edge to produce sharp, clean interface with adjoining materials. Remove tape immediately after joints have been sealed and tooled as directed.

D. Do not install sealants without backer rods or bond breaker tape.

E. Roll the back-up rod stock into the joint to avoid lengthwise stretching. Do not twist, braid, puncture or prime backer-rods.

F. Employ only proven installation techniques, which will ensure that sealants will be deposited in uniform, continuous ribbons without gaps or air pockets, with complete "wetting" of the joint bond surfaces equally on opposite sides. Except as otherwise indicated, fill sealant rabbet to a slightly concave surface, slightly below adjoining surfaces. Where horizontal joints are between a horizontal surface and a vertical surface, fill joint to form a slight cove, so that joint will not trap moisture and dirt.

G. Install sealants to depths as recommended by the sealant manufacturer, but within the following general limitations, measured at the center (thin) section of the bead.
   1. For horizontal joints in sidewalks, pavements and similar locations sealed with elastomeric sealants and subject to traffic and other abrasion and indentation

exposures, fill joints to a depth equal to 75 percent of joint width, but not more than 5/8-inch deep or less than 3/8-inch deep.

2. For vertical joints subjected to normal movement and sealed with elastomeric sealants, but not subject to traffic, fill joints to a depth equal to 50 percent of joint width, but not more than 1/2-inch deep or less than 1/4-inch deep.

H. Remove excess and spillage of compounds promptly as the Work progresses.

I. Cure caulking and sealant compounds in compliance with manufacturer's instructions and recommendations, to obtain high early bond strength, internal cohesive strength and surface durability.

3.4 FIELD QUALITY CONTROL

A. Where questions of compatibility of sealants and substrate arise, the sealant manufacturer shall test the substrate in question for compatibility with the specified sealant and report his findings, along with recommendations, to ENGINEER.

B. Do not proceed with installation of elastomeric sealants over joint surfaces which have been painted, lacquered, waterproofed or treated with water repellent or other treatment or coating unless a laboratory test for durability (adhesion), in compliance with FS TT-S-00227 has successfully demonstrated that sealant bond is not impaired by the coating or treatment. If laboratory test has not been performed, or shows bond interference, remove coating or treatment from joint surfaces before installing sealant.

C. After nominal cure of exterior joint sealants which are exposed to the weather, test for water leaks. Flood the joint exposure with water directed from a 3/4-inch diameter garden hose, without nozzle, held perpendicular to wall face, 2 feet - 0 inch from joint and connected to a water system with 30 psi minimum normal water pressure. Move stream of water along joint at an approximate rate of 20 feet per minute.

D. Test approximately five percent of total joint system, in locations which are typical of every joint condition, and which can be inspected easily for leakage on opposite face. Conduct test in the presence of ENGINEER, who will determine the actual percentage of joints to be tested and the actual period of exposure to water from the hose, based upon the extent of observed leakage, or lack thereof.

E. Where nature of observed leakage indicates the possibility of inadequate joint bond strength, ENGINEER may direct that additional testing be performed at a time when joints are fully cured, and before Substantial Completion of the Work.

3.5 ADJUSTMENT AND CLEANING

A. Repair sealant installation at leaks or, if leakage is excessive, replace sealant installation.

B. Clean adjacent surfaces of sealant and soiling resulting from the Work. Use solvent or cleaning agent recommended by the sealant manufacturer. Leave all finish Work in a neat and clean condition.

C. Protect the sealants during the construction period so that they will be without deterioration, soiling, or damage at the time of Final Completion.

+ + END OF SECTION + +

SECTION 09900

PAINTING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, tools, equipment and incidentals as shown on the Drawings, specified and required to furnish and apply paint systems.
   2. Provide proper surface preparation and painting of all new and existing interior and exterior items and surfaces.
   3. Extent of painting is specified and includes the following:
      a. Painting shown in schedules may not provide a complete indication of all painting work. Check drawings and the coating specifications.
      b. All substrates must be prepared and painted according to their intended location, service environment per the coating manufacturer's current product data sheet for the coating (s) being used, unless specifically identified on the Drawings as a surface not to receive specified painting system.
      c. All new and specifically identified existing surfaces and items except where the natural finish of the material is specified as a corrosion-resistant material not requiring paint; or is specifically shown on the Drawings as indicated by written note, or specified as a surface not to be painted. Where items or surfaces are not specifically mentioned, paint them the same as adjacent similar materials or areas, unless otherwise directed by ENGINEER.
      d. Heating, ventilating, and air conditioning items to be painted include, but are not limited to the following:
         1) Piping, pipe insulation, pipe hangers, and supports.
         2) Heat Exchangers.
         3) Tanks.
         4) Ductwork and insulation.
         5) Motors, mechanical equipment, and supports.
         6) Accessory items.
      e. All new and specifically identified existing surfaces and items except where the natural finish of the material is specified as a corrosion-resistant material not requiring paint; or Surface preparation and painting of all new and specifically identified existing items, both interior and exterior, and other surfaces, including items furnished by OWNER, are included in the Work, except as otherwise shown on the Drawings or specified.
      f. Removal of all substances, top coats, primers and all intermediate coats of paint and other protective or decorative toppings on those items and surfaces to remain that are identified to receive a painting system under this Section, in order to provide surfaces acceptable for application of painting system specified.

g. Approved stepped-down mock-ups for all coating or lining systems showing all components of the surface preparation and coating or lining system application before the start of any work. Check all dry film thicknesses; demonstrate methods of surface preparation and methods of application in addition to obtaining ENGINEER'S approval of colors and textures to be used in the work. Submit all mock ups to the ENGINEER prior to conducting the work.

B. Coordination:
1. Review installation, schedules, removal and demolition procedures under other Sections and coordinate them with the work specified herein.
2. Coordinate the painting of areas that will become inaccessible once equipment, laboratory furniture, lockers and similar fixed items have been installed.
3. Coordinate primers with finish paint materials in order to provide primers that are compatible with finish paint materials used. Review other Sections and other contracts where primed surfaces are provided, to ensure compatibility of the total painting system for the various surfaces and environment service exposures. Coordinate the compatibility of all shop-primed and field-painted items in other Sections.
4. Furnish information to ENGINEER on the characteristics of the finish materials proposed for use, to ensure that compatible prime coats are used. Provide barrier coats over incompatible primers or remove and repaint as required. Notify ENGINEER, in writing, of anticipated problems using the specified painting systems with surfaces primed by others. Repair and re-prime all equipment primed in the factory and other factory-primed items that are damaged or scratched according to the coating manufacturers current written instructions.
5. All shop primed items shall be re-blasted in the field and re-primed prior to being finish coated. No equipment that has been shop primed and finish coated shall be field painted, unless it has been re-blasted, re-primed and finish coated in the field.

C. Work Not Included: The following categories of Work are not included as part of the painting Work, or are included in other Sections:
1. Shop-Priming: Shop-priming of structural metal, miscellaneous metal fabrications, other metal items and fabricated components such as shop-fabricated or factory-built heating and ventilating and electrical equipment or accessories shall conform to applicable requirements of this Section but are included under other Sections.
2. Pre-finished Items:
   a. Items furnished with such finishes as baked-on enamel, porcelain and polyvinylidene fluoride shall only be remediated at the site according to the manufacturers' written instructions and using the manufacturer's recommended compatible field-applied touchup pain
   b. Items furnished with such finishes as chrome plating or anodizing.
3. Concrete surfaces unless otherwise shown on the Drawings or specified.
4. Concrete floors
5. Face brick, glazed structural tile and prefaced, ground-faced or split-faced concrete masonry units.
6. Exterior face of architectural precast concrete.

7. Collector bearings, shafts and chains, wood flights, wood stop logs and wood baffles.
8. Corrosion-Resistant Metal Surfaces: Where the natural oxide of the item forms a barrier to corrosion, whether factory- or site-formed, including such materials as copper, bronze, muntz metal, zinc, terne metal and stainless steel.
9. Operating Parts and Labels:
    a. Do not paint moving parts of operating units, mechanical and electrical parts such as valve and damper operators, linkages, sensing devices, interior of motors and fan shafts.
    b. Do not paint over labels required by governing authorities having jurisdiction, or any equipment identification, performance rating, name or nomenclature plates.
    c. Cover moving parts and labels during the painting Work with protective masking. Remove all protective masking upon completion of Work. Remove all paint, coatings or splatter which comes in contact with such labels.
10. Structural and miscellaneous metals covered with concrete shall only receive a primer compatible with the covering material.
11. Existing structures, equipment and other existing surfaces and items, unless otherwise shown on the Drawings or specified.

D. Description of Colors and Finishes:
    1. Color Selection:
        a. Maximum of 12 different colors shall be selected by ENGINEER, in addition to color- coding of all pipelines, valves, equipment and ducts.
        b. ENGINEER reserves the right to select all non-standard colors for all paint systems specified within the ability of manufacturer to produce such non-standard colors. CONTRACTOR shall supply such colors, at no additional cost to OWNER.
    2. Color Coding of Pipelines, Valves, Equipment and Ducts:
        a. In general, all color-coding of pipelines, valves, equipment and ducts shall comply with applicable standards of ANSI A13.1, ANSI Z535.1 and CFR 1910.144. Provide color-coding for pipelines included in Paragraph 1.1.F.3.b, Pipeline Color Table, for specified pipelines.
        b. For equipment located on roofs or where exposed-to-view such as on exterior building facades, or in offices or lobbies, the color shall be selected by ENGINEER.
    3. Color Coding of Pipelines and Equipment:
        a. Finish coats of paint for pipelines and equipment shall be coded in basic colors. Colors shall be brilliant, distinctive shades matching the following safety colors in accordance with ANSI Z535.1 color specifications for safety colors and other primary colors:

TABLE OF STANDARD COLORS

COLOR	DESIGNATION
Black	Black - 35GR
Blue	Safety Blue - 11SF
Brown	Chipmunk - YB23
Charcoal	Graphite - GR32
Gray	Gray-ANSI 61 - 33GR
Green	Safety Green - 09SF
Light Gray	Light Gray - 32GR
Light Green	Misty Jade - GB38
Orange	Safety Orange - 04SF
Red	Safety Red - 06SF
White	White - 00WH
Yellow	Safety Yellow - 02SF
D. Gray	Sinker - 46GR
Lt. Blue	Clear Sky - 26BL
Dk. Blue	KC Blue - 21BL
Medium Green	Linden - 27GN
Dk. Green	Hunter Green - 08SF
Purple	Safety Purple - 14SF

**Color designations are provided as Tnemec Company, Incorporated paint color numbers and are provided as a standard of quality; equivalent colors matching these colors will be acceptable to ENGINEER. Provide ENGINEER with direct color comparisons of color numbers available from manufacturer submitted at time of Shop Drawing submission.*

4. General Color Code: Unless otherwise specified, the following color code shall be used:

PIPING AND SIGN COLOR CODE

WATER			
PIPING AND LEGEND	PIPING COLOR	LETTERING COLOR	BACKGROUND COLOR
Spray Water	Red	Black	Red
Potable Water	Lt. Blue/White Bands	Black	Blue
Seal Water	Red	White	Red
Chilled Water Return	Blue	White	Green
Chilled Water Supply	Blue	White	Green
Cold Water	Blue	White	Green
Hot Water Return	Blue/Red Bands	Black	Yellow
Hot Water Supply	Blue/Red Bands	Black	Yellow
Non-Potable Water (Reuse Water)	Red/Black Bands	White	Red

WATER LINES			
PIPING AND LEGEND	**PIPING COLOR**	**LETTERING COLOR**	**BACKGROUND COLOR**
Water - Potable	Lt. Blue	Black	None
Water - Potable (HOT)	Lt. Blue	Black	Red
Water - Deionized	Lt. Blue	Black	None
Water - Raw	Dk. Green	Black	Lt. Gray
Water - Non Potable (Plant Water)	Lt. Blue	Black	Purple
Water - Non Potable (Reuse)	Purple	Black	None

SAMPLE LINE PIPING			
PIPING AND LEGEND	**PIPING COLOR**	**LETTERING COLOR**	**BACKGROUND COLOR**
Raw Water	Dk. Blue	White	Black
Non Raw Water	Dk. Blue	Black	Lt. Blue

AIR AND GAS			
PIPING AND LEGEND	**PIPING COLOR**	**LETTERING COLOR**	**BACKGROUND COLOR**
Process Air	White	Black	White
Chlorine Gas	Yellow/Green Bands	White	Yellow
Natural Gas	Red	Black	Yellow
Digester Gas, H.P.	Red	Black	Yellow
Digester Gas, L.P.	Red	Black	Yellow
High Pressure Air	White/Red Bands	Black	White

CHEMICALS			
PIPING AND LEGEND	**PIPING COLOR**	**LETTERING COLOR**	**BACKGROUND COLOR**
Ferric Chloride	Safety Orange	Black	Safety Orange
Chlorine Solution	Yellow	Black	Yellow
Liquid Polymer	Yellow	Black	Yellow
Polymer Feed	Yellow	Black	Yellow
Methanol	Yellow	Black	Yellow
Sodium Hydroxide	Yellow	Black	Yellow
Sodium Hypochlorite	Yellow	Black	Yellow
Hydrochloric Acid	Yellow	Black	Yellow

PROCESS			
PIPING AND LEGEND	**PIPING COLOR**	**LETTERING COLOR**	**BACKGROUND COLOR**
Primary Effluent	Brown	Black	Green
Digester Tank Drains	Brown	Black	Green
Floor Drains	Gray	Black	Green
Settling Tank Drains	Gray	Black	Green
Storage Tank Drains	Gray	Black	Green
Storm Drains	Gray	Black	Green
Sump Drains	Gray	Black	Green
Mixed Liquor	Brown	Black	Green
Scum	Black	Black	Green
Sewage D.	Gray	Black	Green
Sewage Sampling Lines	D. Gray	Black	Green
Sludge	Brown	Black	Green
Digested Sludge	Brown	Black	Green
Primary Sludge	Brown	Black	Green
Raw Sludge	Brown	Black	Green
Recirculated Digester Sludge	Brown	Black	Green
Return Activated Sludge	Brown	Black	Green
Waste Activated Sludge	Brown	Black	Green
Supernatant	Black	Black	Green
Digester Tank Over-flow	Brown	Black	Green
Storage Tank Over-flow	Brown	Black	Green
Grit Lines	Brown	Black	Yellow
Grit Overflow	Brown	Black	Yellow
Grit Dewatering	Brown	Black	Yellow
Centrate Lines	Gray	Black	Yellow
Sludge Cake Lines	Brown	White	Green
Scrubber Blowdown	Yellow	Black	Yellow

PROCESS CHEMICAL SOLUTIONS			
PIPING AND LEGEND	**PIPING COLOR**	**LETTERING COLOR**	**BACKGROUND COLOR**
Alum	Medium Green	Black	None
Ferric Chloride	Orange	White	Black
Polymer - Coagulant	Lt. Green	Green	Lt. Blue
Polymer - Filter Aid	Lt. Green	White	Dk. Blue
Polymer - Thickener	Lt. Green	White	Dk. Blue
Polymer - Centrifuge	Lt. Green	White	Dk. Blue
Polyphosphate	Medium Green	Black	None
Carbon	Black	White	None
Sulfuric Acid	Yellow	Black	Red
Caustic Soda	Dk. Green	White	None
Lime	Medium Green	Black	None
Fluoride	Yellow	Black	Lt. Blue
Copper Sulfate	Medium Green	Black	Blue

DISINFECTANTS			
PIPING AND LEGEND	**PIPING COLOR**	**LETTERING COLOR**	**BACKGROUND COLOR**
Chlorine - Gas	Yellow	Black	Green
Chlorine - Liquid	Yellow	Black	None
Chlorine - Solution	Yellow	Black	None

PLANT AIR			
PIPING AND LEGEND	**PIPING COLOR**	**LETTERING COLOR**	**BACKGROUND COLOR**
Plant Air Piping	White	Black	None
High Pressure Air Piping	White	Black	Red

WASTEWATER			
PIPING AND LEGEND	**PIPING COLOR**	**LETTERING COLOR**	**BACKGROUND COLOR**
Domestic Wastewater	Gray	Black	None
Process Wastewater	Gray	Black	Lt. Blue

FIRE QUENCHING MATERIALS		
Water, Foam, CO2, Halon, Fire Hydrants, including sections of potable water for Fire Dept. access (no label)		
PIPING COLOR	**LETTERING COLOR**	**BACKGROUND COLOR**
Red	None	None

USED WATER RECOVERY FACILITIES			
PIPING AND LEGEND	**PIPING COLOR**	**LETTERING COLOR**	**BACKGROUND COLOR**
Floor Drains	Gray	Black	Green
Settling Tank Drains	Gray	Black	Green
Storage Tank Drains	Gray	Black	Green
Sump Drains	Gray	Black	Green
Scum	Brown	Black	Green
Sludge	Brown	Black	Green
Storage Tank Over-flow	Brown	Black	Green

OTHER			
PIPING AND LEGEND	**PIPING COLOR**	**LETTERING COLOR**	**BACKGROUND COLOR**
Lube Oil	Brown	White	Brown
Waste Oil	Brown	White	Brown
Roof Drains	Gray	Black	Green
Methanol Solution	Yellow	Black	Yellow
Natural Gas	Orange	Black	Lt. Blue

5. After approval by ENGINEER of colors and Shop Drawing submittals and prior to beginning painting Work, ENGINEER will furnish color schedules for surfaces to be painted.
6. Abbreviations and Symbols:
   a. Abbreviations and symbols used in Tables are explained in Article 2.2, below, and provide information on generic composition of the required materials, manufacturers, number of coats and their dry mil film thickness per coat (DMFTPC) and coverage for calculating the required number of gallons for the Work.

1.2 REFERENCE STANDARDS

A. Insure all referenced standards are used according to the standard's most current version.

B. ASTM International (ASTM):

1. ASTM C 1538/1538M, Tensile Strength of Concrete Surfaces and the Bond Strength or Tensile Strength of Concrete Repair and Overlay Materials by Direct Tension (Pull-Off Method
2. ASTM D 16, Standard Terminology Relating to Paint, Varnish, Lacquer and Related Products
3. ASTM D 3359, Methods for Measuring Adhesion by Tape Test. Method A.
4. ASTM D 3960, Practice for Determining Volatile Organic Compound (VOC) Content of Paints and Related Coating
5. ASTM D 4227, Standard Practice for Qualification of Coating Applicators for Application of Coatings to Concrete Surfaces
6. ASTM D 4228, Standard Practice for Qualification of Coating Applicators for Application of Coatings to Steel Surfaces
7. ASTM D 4258, Practice for Surface Cleaning Concrete for Coating.
8. ASTM D 4259, Practice for Abrading Concrete.
9. ASTM D 4261, Standard Practice for Surface Cleaning Concrete Unit Masonry for Coating.
10. ASTM D 4262, Standard Test Method for pH of Chemically Cleaned or Etched Concrete Surface
11. ASTM D 4263, Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method.
12. ASTM D 4285, Test Method for Indicating Oil or Water in Compressed Air.
13. ASTM D 4417, Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel. Methods B or C
14. ASTM D 4541, Test Method for Pull-Off Strength of Coatings Using Portable Adhesion-Testers.
15. ASTM D 6386, Standard Practice for Preparation of Zinc (Hot-Dip Galvanized) Coated Iron and Steel Product and Hardware Surfaces for Painting
16. ASTM D 7234, Pull-Off Adhesion test of Coatings on Concrete Using Portable Pull-Off Adhesion Testers
17. ASTM E 84, Standard Test Method for Surface Burning Characteristics of Building Materials
18. ASTM E 797/797M, Measuring Thickness by Manuel Ultrasonic Pulse-Echo Contact Method
19. ASTM F 22, Hydrophobic Surface Films by the Water Break Test
20. ASTM F 1869, Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride
21. ASTM F 2170, Determining Relative Humidity in Concrete Floor Slabs Using in situ Probes the Identification of Piping Systems.

C. American National Standards Institute (ANSI)/NSF International (NSF)
   1. ANSI A13.1, Scheme for the Identification of Piping Systems
   2. ANSI Z535.1, Safety Color Code.
   3. ANSI/NSF Standard 60, Drinking Water Chemicals - Health Effects.
   4. ANSI/NSF Standard 61, Drinking Water System Components - Health Effects.

D. NACE International (NACE)
   1. NACE SP0188, (Standard Practice Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates0
   2. NACE SP0892, Standard Practice for Coatings and Linings over Concrete for Chemical Immersion and Containment Service.
   3. NACE Publication 6D-173, A Manual for Painter Safety

E. National Bureau of Standards (NBS)
   1. Certified Coating Thickness Calibration Standards.

F. National Fire Protection Association (NFPA)
   1. 101, Life Safety Code.

G. The Society for Protective Coatings (SSPC)
   1. PA 2, Procedure for Determining Conformance to Dry Coating Thickness Requirements (Level 3)
   2. SP 1, Solvent Cleaning
   3. SP 2, Hand Tool Cleaning
   4. SP 3, Power Tool Cleaning
   5. SP-15, Commercial Grade Power-Tool Cleaning
   6. SSPC Painting Manuel Volume 1, Good Painting Practice Structures
   7. SSPC - Volume 2, Systems and Specifications.
   8. SSPC - VIS 1, Visual Standard for Abrasive Blast Cleaned Steel.
   9. SSPC - VIS 2, Visual Standard for Evaluating Degree of Rusting on Painted Steel Surfaces
   10. SSPC VIS 3, Guide and Reference Photographs for Steel Surfaces Prepared By Power and Hand Tool Cleaning
   11. SSPC Guide 6, Containing Debris Generated During Paint Removal Operation
   12. SSPC Guide 12, Guide for Illumination of Industrial Projects

H. The Society for Protective Coatings/NACE International (SSPC/NACE)
   1. SP 5/NACE NO. 1, White Metal Blast Cleaning
   2. SP 10/NACE No. 2, Near-White Blast Cleaning
   3. SP 6/NACE No.3, Commercial Blast Cleaning
   4. SP 7/NACE No. 4, Brush-off Blast Cleaning
   5. SP 13/NACE No. 6, Surface Preparation of Concrete

I. National Association of Pipe Fabricators, Inc.
   1. NAPF 500-03 (SURFACE PREPARATION STANDARD FOR DUCTILE IRON PIPE AND FITTINGS IN EXPOSED LOCATIONS RECEIVING SPECIAL EXTERNAL COATINGS AND/OR SPECIAL INTERNAL LININGS
   2. 500-03-01, Solvent Cleaning
   3. 500-03-02, Hand Tool Cleaning
   4. 500-03 -03, Poor Tool Cleaning
   5. 500-03-04, Abrasive Blast Cleaning for Ductile Iron Pipe

6. 500-03-05, Abrasive Blast Cleaning for Cast Ductile Iron Fittings

J. The International Organization for Standardization (ISO)
   1. ISO 8502-3, Preparation of steel substrates before application of paint and related products -Tests for the assessment of surface cleanliness - Part 3: Assessment of dust on steel surfaces prepared for painting (pressure-sensitive tape method)

K. Code of Federal Regulations
   1. 29 CFR 1910.144, Safety Color Code for Marking Physical Hazards.

1.3 DEFINITIONS

A. Specific coating terminology used in this Section shall be in accordance with the definitions in ASTM D 16, ASTM D 3960 and the following definitions:
   1. The term "paint" includes pretreatment and all painting system materials, such as primer, emulsion, enamel, organic/inorganic polymer coating, stain sealer and filler, and other applied materials whether used as prime, filler, intermediate or finish coats.
   2. The term “resurfacer” as used herein means an epoxy polymer modified cementitious material used to restore the concrete substrate to provide a contiguous concrete surface for subsequent lining materials.
   3. The term “coating” and “lining” as used herein are considered interchangeable and mean coating systems materials, including any applicable resinous primers and finish coats that function to provide protection of steel or concrete substrates.
   4. The terms “coating system” and “lining system” as used herein are considered interchangeable and mean all total resurfacing and coating materials combined to function as a total system to provide the designed protection
   5. The term "exposed" means all items not covered with cement plaster, concrete or fireproofing. Items covered with these materials shall be provided with specified primer only, except where specified as a surface not to be painted. Exposed-to-view surfaces also include those areas visible after permanent or built in fixtures, convector covers, ceiling tile, covers for finned tube radiation, grilles, etc. are in-place, in areas scheduled to be painted.
   6. Dry Film Thickness (DFT): The thickness of one fully cured continuous application of coating.
   7. Field Coat: The application or the completion of application of the coating system after installation of the surface at the site of the Work.
   8. Shop Coat: One or more coats applied in a shop or plant prior to shipment to the site of erection or fabrication, where the field or finishing coat is applied.
   9. Barrier Coat:. A physical barrier, i.e. coating, between the substrate and it’s environment by keeping oxygen, moisture and other chemicals away from the substrate
   10. Photochemically Reactive Organic Material: Any organic material that will react with oxygen, excited oxygen, ozone or other free radicals generated by the action of sunlight on components in the atmosphere giving rise to secondary contaminants and reaction intermediates in the atmosphere which can have detrimental effects.

11. Volatile Organic Compound (VOC) Content: The portion of the coating that is a compound of carbon, is photochemically reactive, and evaporates during drying or curing, expressed in grams per liter or pounds per gallon.
12. Touch-Up Painting: The application of a paint on areas of painted surfaces to repair marks, scratches, and areas where the coating has deteriorated to restore the coating film to an unbroken condition.
13. Painter: Installer or applicator is the person or persons actually installing or applying the coating and/or lining in the field at the Project site.
14. The term Independent NACE CCI 3: The inspection body and its staff shall not engage in any activities that may conflict with their independence of judgment and integrity in relation to their inspection activities. In particular they shall not become directly involved in the design, manufacture, supply, installation, user or maintenance of the items inspected, or similar competitive items. They are also a person and/or persons (NACE Certified Coating Inspector) that has satisfactorily completed NACE CIP program and is still actively certified by NACE International.
15. Approved Factory Finish: Finish on a product in compliance with the finish specified in the section where the product is specified.
16. Corrosive Environment: Immersion in, or not more than 6 IN above, or subject to frequent condensation, spillage or splash of a corrosive material such as water, wastewater, or chemical solution; or chronic exposure to corrosive, caustic or acidic agent, chemicals, chemical fumes, chemical mixture, or solutions with pH range of 5 - 9.
17. Highly Corrosive Environment: Immersion in, or not more than 6 IN above, or subject to frequent condensation, spillage or splash of a corrosive material such as water, wastewater, or chemical solution; or chronic exposure to corrosive, caustic or acidic agent, chemicals, chemical fumes, chemical mixture, or solutions with pH range below 5 or above 9.
18. Holiday: A void, crack, thin spot, foreign inclusion, or contamination in the coating film that significantly lowers the dielectric strength of the coating. May also be identified as a holiday or pinhole.
19. Submerged Metal: Steel or iron surfaces below tops of channel or structure walls which will contain water even when above expected water level.
20. Exposed Surface: Any metal or concrete surface, indoors or outdoors that is exposed to view.
21. Dry Film Thickness (DFT): Thickness of fully cured coating, measured in mils (1/1000 inch).
22. 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.
23. Ferrous: Cast iron, ductile iron, wrought iron, and all steel alloys except stainless steel.

1.4 QUALITY ASSURANCE

A. Applicators' Requirements

1. If any requirements of this specification in conflict with a referenced standard, the more stringent requirement shall apply.
2. Minimum of 10 (ten) years of experience regularly performing the application of coating and/or lining materials, with documented skill and successful experience in the application of the types of materials.
3. Submit list of projects of similar size and complexity along with names of persons and their work experience. This must include evidence of worker training and qualification programs. Only those submitted and approved persons by the ENGINEER will be permitted to work on the project.
4. Qualifying experience shall include at least three previous projects of similar magnitude and complexity to this project that have been completed not less than 18 months prior to submission of qualifications to ENGINEER.
5. Submit name and qualifications to ENGINEER along with the following information on a minimum of three successful projects:
   a. Name of project
   b. Names and telephone numbers of owners, architects or engineers responsible for projects.
   c. Approximate contract cost of the paint materials.
   d. Amount of area installed.
6. Submit in writing to the ENGINEER acceptability by the coating manufacturer.
7. Personnel are to be completely trained and experienced in the proper use of all specified/submitted coating and lining materials, surface preparation and application equipment being used for the project. No person shall work on this project unless they have been previously approved by the ENGINEER.

B. Source Quality Control
   1. Obtain materials only from manufacturers who will provide the services of a qualified manufacturer's representative at the site at the commencement of painting Work to advise on materials, mock-ups, installation and finishing techniques, at the completion of the Work to advise ENGINEER on the acceptability of completed Work, and during the course of the Work as may be requested by ENGINEER.
   2. Certify long-term compatibility of all coatings with intended service exposures.
   3. Do not submit products that do not meet or exceed the performance criteria. All submitted coating and/or lining system must be able to provide long-term protection and performance within its intended service environment. Products exceeding current VOC limits will not be approved.
   4. ENGINEER may review manufacturer’s recommendations concerning methods of installation and number of coats of paint for each painting system. Prepare cost estimates based on painting systems, number of coats, coverages and installation methods specified.
   5. All proposed "or equal" products shall be submitted 20 working days prior to the beginning of work with direct comparison to products specified including information on performance criteria adhesion, color and gloss retention, percent solids, VOC's per gallon, application methods, case histories and re-coat ability after curing etc.

6. "Equal or better" manufacturers shall furnish the same color selection as the manufacturers specified, including intense chroma and custom pigmented colors in all painting systems.
7. Color Pigments: Provide pure, nonfading, applicable types to suit the surfaces and services indicated. Comply with the following:
   a. Lead and Chromate: Lead and chromate content shall not exceed amount permitted by governing authorities having jurisdiction.
   b. Areas subject to hydrogen sulfide fume exposure shall be identified by ENGINEER. Manufacturer shall notify ENGINEER of colors that are not suitable for long-term color retention in such areas.
   c. Comply with manufacturer's recommendations on preventing coating contact with levels of carbon dioxide and carbon monoxide that may cause yellowing during application and initial stages of curing of paint coatings.
8. Obtain each product from only one manufacturer. Multiple manufacturing sources for the same system component will not be approved by ENGINEER.
9. Certify product shelf life history for each product source for materials manufactured by the same manufacturer, but purchased and stored at different locations or obtained from different sources.
10. Constantly store materials to be used in the painting according with the manufacturers approved current written recommendations, for not more than six months. Certify to ENGINEER that painting materials have been manufactured within six months of installation and have not, nor will be, subjected to freezing temperatures.
11. Provide the services of a qualified manufacturer's representative to the Project site to observe the initial commencement of surface preparation and each coating's application. Manufacturer's representative will advise on materials, surface preparation, coating applications and finishing techniques. Once completed the manufacturer's representative will provide a written report certifying that all observed surface preparation and coating application(s) have been completed according to the manufacturer's current recommendations and requirements. This certification report must be received 7 (seven) calendar days after the last site visit by the manufacturer.
12. Provide in writing that the specified and applied coating or lining system is the correct system for the long-term protection and performance of the environmental exposures it will be subjected.
13. Provide the services of a qualified manufacturer's representative to the Project site at the completion of work to inspect the Work. The qualified manufacturer's representative to provide a manufacturer's report stating any deficiencies in the coatings system, if any, noted during the final inspection. The report must be submitted to the ENGINEEER 7 (seven) calendar days after the last site visit by the manufacturer.
14. Following the completion of the corrective measures, provide the services of an independent NACE CCI to re-inspect the work. Within 7 (seven) days after re-inspection, the independent NACE CCI will provide a written report to the ENGINEEER stating that the coatings have been applied properly and in accordance with the manufacturer's written recommendations and requirements.

C. Testing Qualifications: To qualify for approval, provide all required documented performance criteria and project cases histories of more than 5 (five) years of service in similar or more severe environments. Provided information must clearly demonstrate to ENGINEER'S satisfaction that the submitted coating or lining system performance criteria data and project case histories meets or exceeds the projects intended environmental service requirements.

D. Stepped-Down Mock-Ups
   1. Demonstrate installation of specified coating or lining system(s) on actual surfaces and building components at locations selected by ENGINEER.
   2. Once the ENGINEER has approved in writing all the components of coating or lining system. Provide a 3 foot by 3 foot (minimum) stepped-down sample area for each specified system according to specified manufacturer's most current written application recommendations. Each surface preparation and application step shall remain exposed in order to demonstrate the Work performed by that step. Each step of the mock up must be approved in writing by the ENGINEER and coating manufacturer representative. Continue application procedures until topcoat is provided.
   3. Finished mock-up for each coating or lining system, when completed, shall reveal each step and each coat of paint required for the specified. Mock up standard must be protected and preserved until the application completion and written acceptance of the work for that particular specified system. Use tinted shades differing from coat to coat for each component of each painting system. All mock-up work must be done by person(s) that will actually be doing the work on the project. Utilize ASTM D 4227 Standard Practice for Qualification of Coating Applicators for Application of Coatings to Concrete Surfaces or ASTM D 4228 Standard Practice for Qualification of Coating Applicators for Application of Coatings to Steel Surfaces.
   4. ENGINEER may approve or disapprove each component of each painting system on an individual component basis.
   5. Coating or lining system Work that does not meet the standard approved on the sample areas shall be removed and replaced with new material.
   6. Coating or lining system Work advanced without approved mock-ups shall be stopped, and mock-ups prepared for approval by ENGINEER. If any coatings or linings have been applied before an approved mock up standard has been agreed upon in writing by all parties, the ENGINEER has the authority to have those applied coatings or linings completely removed and reapplied at CONTRACTORS expense.

E. Requirements of Regulatory Agencies: Surface preparation and application of coatings shall be performed in compliance with all applicable federal, state and local occupational safety and health regulations and Maricopa County Air Pollution Control Regulations. Insure that all required certifications for all regulatory agencies current and readily available upon request.
   1. Obtain and comply with all safety precautions recommended by the paint manufacturer in printed instructions or special bulletins and as required by applicable regulations. Provide forced ventilation in all areas where inadequate ventilation exists.

2. Painting systems for surfaces in contact with potable water, or water being treated for potable use, shall be NSF approved and shall not impart any taste or odor to the water or result in any organic or inorganic content in excess of the maximum allowable contaminant level established by governing authorities having jurisdiction. All such painting systems shall be approved by the applicable regulatory agency. Revise painting systems specified herein to provide manufacturer's regulatory agency approved painting system(s) where required.
3. Comply with the regulations of governing authorities having jurisdiction for air quality and material disposal regulations. Revise painting systems specified herein in order to provide manufacturer's regulatory agency approved painting systems, where required.
4. Comply with governing authorities having jurisdiction for blast cleaning operations, confined space entry and disposition of spent abrasive and debris.

F. Pre-Application Meeting:
   1. A pre-application meeting MUST take place at the job-site or mutually agreed upon site a minimum 3 (three) weeks before the application of any coating or lining work proceeding. Attendance is required of all principal decision making parties directly affecting work of this section, including OWNER, ENGINEER, CONTRACTOR, COATING MANUFACTURER'S REPRESENTATIVE and COATING INSPECTOR etc. Record the discussions of the conference and the decisions and agreements (or disagreements) and furnish a copy of the record to each party attending. Review foreseeable methods and procedures relating to the painting Work, including but not necessarily limited to, the following:
      a. Review Project Coating Specification, Project requirements, including Contract Documents, Project Schedule, approved Shop Drawings, pending and approved Change Orders and requests for information.
      b. Field quality control: Contractors responsibilities, i.e providing written daily reports and review required samples and submittals, both completed and yet to be completed.
      c. Review status of surfaces including drying, surface preparations and similar considerations.
      d. Review availability of materials, tradesman, equipment and facilities needed to make progress, avoid delays and protect the Work from damaging conditions.
      e. Coating Inspector's authority and responsibilities, required inspections, testing services, certifications and quality control procedures.
      f. Review weather and forecasted weather conditions, and procedures for coping with unfavorable conditions. Supplemental heating sources, as may be required to continue the Work under low temperature conditions, shall be in operating order and acceptable to paint applicator.
      g. Review methods for complying with regulations of governing authorities having jurisdiction, such as compliance with environmental protection, health, safety, fire and similar regulations.
      h. Material storage requirements
      i. Protection of surfaces not scheduled to be coated

j. Application requirements and procedures
k. Protection of coating systems

2. Provide meeting minutes to all parties for review and possible clarification. Should any correction to the meeting minutes be required, the minutes should be corrected and resubmitted to all parties.
3. Reconvene the meeting at the earliest opportunity if additional information must be developed in order to conclude the subjects under consideration.
4. Record any revisions or changes agreed upon, reasons therefore, and parties agreeing or disagreeing with them.

G. Maintain a Paint Application Log containing the information as shown on the log attached at the end of this Section. The Paint Application Log shall be maintained on a daily basis for all areas where the Work is being performed. The Paint Application Log shall be turned over to the ENGINEER by 9:00 a.m. the following day that the work was performed. The log shall include the following:
1. Date.
2. Time.
3. Weather condition (at work location).
4. Air temperature (at work location).
5. Surface temperature (at work location).
6. Dew point (at work location).
7. Humidity (at work location).
8. Material temperature (Before (Separately) and Mixed (Combined)
9. Location/area square footage.
10. Description of Work performed.
11. Materials used, colors and batch numbers, quantity of materials used (not including waste).
12. Application/surface preparation equipment and personnel.
13. WFT/surface profile measurements.
14. Comments, quality control procedures.
15. Signature/title.

1.5 SUBMITTALS

A. Samples: Submit for approval the following:
1. Copies of manufacturer's complete color charts for each coating system.

B. Shop Drawings: Submit for approval the following:
1. Copies of manufacturer's current technical information and test performance data, including paint analysis, VOC content in comparison to current legal maximum limits allowed, and current application instructions for each material proposed for use.
2. Submit Applicator's Qualifications in accordance with 1.4 Quality Assurance. No submittal information will be reviewed until Engineer has received and approved applicator qualifications.
3. Product technical data including:

a. Acknowledgement that products submitted meet requirements of standards referenced.
b. Manufacturer's current written application instructions for submitted coating and/or lining systems.
c. Manufacturer's current written repair procedure for the submitted coating and/or lining system.
d. Manufacturer's current written repair procedure for the submitted coating and/or lining system.
e. Manufacturer's current surface preparation instructions for submitted coating and/or lining systems.
f. Manufacturers current written repair procedures for submitted coating and/or systems
g. Written plan of action for containing airborne particles created by blasting operation and location of disposal of spent contaminated blasting media.
h. Coating manufacturer's recommendation on abrasive blasting or other acceptable surface preparation techniques.
i. Coating manufacturer's recommendation for universal barrier coat if required.
j. Coating manufacturer's recommendation for providing temporary or supplemental heat or dehumidification or other environmental control measures.

4. Coating manufacturer's statement regarding applicator instruction on product use.
5. Provide certification that the coating and/or lining systems proposed for use has been reviewed and approved by Senior Technical Service Representative or equivalent employed by the coating manufacturer.
6. Provide a certification from the local coating manufacturer's representative that they have inspected all surfaces with existing coatings and certify that the products are compatible with the existing coatings and the surface preparation requirements required by this Section where appropriate. This certification will be based upon written documented results of an adhesion test (s) performed by a qualified independent NACE CCI Level 3 or Level 2 if directly supervised by a NACE CCI Level 3.
7. Provide all appropriate air quality permits for abrasive blast operation, if required by local, county, state or federal laws or ordinances.

C. Samples:
1. Manufacturer's full line of colors for Engineer's preliminary color selection.
2. After preliminary color selection by Engineer provide two (2) 3 x 5 inch samples of each final color selected.

1.6 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Delivery: Deliver materials to site in manufacturer's original, unopened containers and packaging, with labels clearly identifying.
1. Coating or material name
2. Manufacture
3. Color name and number
4. Batch or lot number

5. Date of manufacture.
6. Mixing and thinning instructions.
7. Federal Specification Number if applicable.
8. Application and mixing instructions.
9. Hazardous material identification label
10. Shelf life date.
11. Storage requirements. Submit storage and application temperature requirements for all coating system materials

A. Storage of Materials:
1. Store materials in a clean dry area and within temperature range according to the coating manufacturer's current written instructions
2. Keep containers sealed until ready for use.
3. Do not use materials beyond manufacturer's shelf life limits.
4. All coating shall be delivered to the shop or job site in original, unopened containers with labels intact. Minor damage to containers is acceptable provided the container has not been punctured or the lid seal broken.
5. Each container of coating shall be clearly marked or labeled to show coating identification, date of manufacture, batch number, and other information as needed to meet regulatory requirements. Each type of coating shall be accompanied by the manufacturer's Material Safety Data Sheet (MSDS) and product data sheet containing information such as basic chemical composition, acceptable weather conditions for application, and proper storing and mixing.
6. All containers of coating shall remain unopened until required for use. No more containers of coating shall be opened than will be applied that day. The label information shall be legible and shall be checked at the time of use.
7. Coating which has livered, gelled, or otherwise deteriorated during storage shall not be used; however, thixotropic materials which can be stirred to attain normal consistency may be used.
8. The oldest coating of each kind that is in acceptable condition shall be used first. In every case, the coating is to be used before its shelf life has expired. Materials exceeding storage life recommended by the Manufacturer shall be removed from the site.
9. Coatings shall be stored in original unopened containers in weather tight spaces where the temperature is maintained between 60 °F and 90 °F unless otherwise recommended in writing by the manufacturer. The coating temperature shall be brought to the coating manufacturer current written recommended application temperature before use. Materials shall be stored according to the manufacturer's recommendations in enclosed structures and shall be protected from weather and adverse temperature conditions.
9. Flammable materials shall be stored according to state and local codes.
10. Store all materials only in area or areas designated by the ENGINEER. Confine mixing, thinning, clean up and associated operations, and storage of materials related debris before authorized disposal, to these areas. All materials are to be stored on pallets or similar storage handling skids off the ground.

11. Mix all lining materials in an enclosed mixing area designated by the ENGINEER. This enclosed area must protect the mixing operation and materials from direct sunlight, inclement weather, freezing, or other means of damage or contamination. Protect all other concrete and metallic surfaces and finishes from any spillage of material(s) within the mixing area. The material temperature should be between 70o F and 90o F before application, unless noted otherwise on the current product data sheet.
12. Do not use floor drains, dikes or storm drains for disposal of coating system materials. Provide for the safe removal and lawful disposal of all waste materials.
13. Take all precautions and implement all measures necessary to avert potential hazards associated with the resurfacing system materials as described on the pertinent Material Safety Data Sheets or container labels.
14. Deliver all materials to the job site in their original, unopened containers. Each container shall bear the Manufacturer's name and label.
15. Maintain the storage and the environmental climate of that area for all coating materials that they will be using unless otherwise agreed upon.
16. Handling: Protect materials during handling and application to prevent damage or contamination.

1.7 SAFETY

A. Conduct the following safety items:
   1. Comply with all federal, state and local regulations as well as with the provisions outlined in NACE Pub. 6D-173, "A Manual for Painter Safety"
   2. Provide personnel with all safety equipment necessary to protect them during any phase of the work according to all current OSHA Standards.
   3. Adhere to all OSHA requirements with regard to permitted confined space including providing all equipment and personnel necessary.
   4. Erect and maintain scaffolding according to OSHA standards.
   5. No work shall be performed until the appropriate Work Requests and Lockouts are approved by the ENGINEER. The Work Request system provides a mechanism to advise plant staff of a contractor's work activities. The Lock Out /Tag Out system is a safety procedure to prevent unintended equipment activation.
   6. Keep any flammable materials such as cleaning solvents, thinners, or resurfacing materials away from open flames, sparks or temperatures higher than 150 F. Drums containing flammable materials shall be grounded. Flammable materials not being utilized shall be maintained in their on-site storage area.
   7. Power tools are to be in good working order to avoid open sparking. No spark producing tools shall be utilized in restricted areas as indicated herein.
   8. Maintain a clean work area and furnish Underwriter's Laboratories approved fire extinguishers on-hand.
   9. Workers performing abrasive blasting operations shall wear a fresh air supplied protective helmet and hood and personal protective clothing acceptable to industry standards and all government regulations.

10. Workers performing coating operations shall wear the appropriate personal protective equipment, clothing, and NIOSH approved respirator acceptable to industry standards and all government regulations.
11. Dispose of rags used for wiping up resurfacing materials, solvents, and thinners by drenching them with water and placing in a metal container with a tight fitting metal cover. Complete this disposal process at the end of each day. Final disposal of these materials is the CONTRACTORS's responsibility.
12. Matches, flames, or sparks resulting from any source including welding, must be removed from the work area during coating work. Smoking is NOT permitted accept for designated areas.

1.8 PROJECT CONDITIONS

A. Site Facilities:
   1. Supplemental heat sources, as may be required to maintain both ambient and surface temperatures within the range recommended by the manufacturer for paint system applications, are not available at the site.
   2. Provide provisions for all supplemental heat energy sources, power, equipment and operating, maintenance and temperature monitoring personnel.
   3. Do not use heat sources, which emit carbon dioxide or carbon monoxide into areas being painted. Properly locate and vent all such heat sources to the exterior such that paint systems are unaffected by exhaust products.

B. Existing Conditions:
   1. Provide lighting (If Required) for all work areas as prescribed in SSPC Guide 12
   2. Existing materials specified to be painted as part of the Work shall have their surfaces prepared to meet the requirements of the painting systems specified. Where existing paint systems will provide the substrate for painting systems specified, provide adhesion testing on existing surfaces to be painted according to the coating manufacturers recommendations. Abrasive blasting, scraping or other abrading or surface film removal, or preparatory techniques as approved by ENGINEER shall be provided as part of the Work.
   3. Before painting is started in any area, all surfaces to be painted and floors shall be cleaned of all dust using commercial vacuum cleaning equipment and dust containment.
   4. Apply coatings to dust free surfaces. Test surfaces for cleanliness according to ISO 8502-3 (Preparation of steel substrates before application of paint and related products -Tests for the assessment of surface cleanliness - Part 3 Assessment of dust on steel surfaces prepared for painting (pressure- sensitive tape method). Randomly test prepared surfaces at rate of 8 tests for the first 1000 square feet. Afterwards conduct 3 tests for each additional 1000 square feet. Provide 3 additional tests for each failed test or questionable test. Turn in test tapes results with Daily Inspection Reports.
   5. After painting operations begin in a given area cleaning shall be done only with commercial vacuum cleaning equipment and dust containment systems.

C. Environmental Requirements

1. If required to maintain project schedule, Provide and utilize dehumidification and ventilation equipment to control humidity, temperature, and vapor levels in from beginning of the surface preparation process through coating application and for seven days after the last coating is applied. System shall maintain vapor concentrations at or below 10 percent of Lower Explosive Limit (LEL). System may incorporate any combination of solid desiccant and direct expansion refrigeration equipment. No liquid, granular, calcium chloride, or lithium chloride drying systems will be accepted. Use only electric, indirect fired combustion, indirect friction, or steam coil auxiliary heaters. System shall be compatible with removal of dust and solvent vapors, and shall have fail-safe measures to ensure reliability during operations.
2. If dehumidification and ventilation equipment is not already being used, ventilate interior areas such as water tanks (potable or non-potable) and other containment service areas according to written procedures outlined by the ENGINEER and/or the coating manufacturer.
3. Provide enclosures for other areas or items that may require protection from the inclement weather or other detrimental effects so the project can continue.
4. Apply water-base paints only when the temperature of surfaces to be painted and the surrounding air temperatures are between 55°F and 90°F, unless otherwise permitted by the paint manufacturer's current printed instructions.
5. Surfaces to be painted shall dry to the touch and at least 5°F above the dew point temperature and rising. Apply paints only when the temperature of surfaces to be painted, paint material, and the surrounding air temperatures are between 65°F and 95°F, unless otherwise permitted by the paint manufacturer's current printed instructions.
6. Apply paint system within the shortest possible time consistent with manufacturer's approved recommended curing instructions for each coat. If chemical, salt, or other contamination contacts paint film between coats, it shall be removed according to the coating manufacturer written recommendation, and the surface restored before applying the remainder of the coatings.
7. Tanks containing water shall not be painted without specific permission of ENGINEER, and only under conditions where "sweating" of the tank outside surface is not likely to occur within 24 hours of application.
8. Epoxy paints shall not be applied if ambient temperature is expected to go below 50°F within 12 hours of application. Where manufacturer's printed recommendations require a higher minimum ambient temperature, this shall be followed.
9. Do not apply paint in rain, fog or mist; or when the relative humidity exceeds 85 percent; to damp or wet surfaces or when surfaces will reach dew point due to falling or rising temperatures and humidity conditions during the course of the paint application, unless otherwise permitted in writing by the paint manufacturer's printed instructions.
10. Do not paint pipelines and other hot or cold surfaces until such surfaces can be maintained within temperature and dew point ranges acceptable to manufacturer. Ar-

range for such surfaces to be brought within acceptable temperature and dew point ranges as part of the painting Work.

11. On substrates such as wood, concrete etc, use methods recommended by the specified manufacturer, the measured moisture content of surfaces shall be verified by the ENGINEER as acceptable prior to the commencement of the painting.
12. Painting may continue during inclement weather only if the areas and surfaces to be painted are enclosed and ambient conditions can be maintained continuously as specified by the paint manufacturer during application and drying periods.
13. Provide adequate illumination (SSPC-Guide 12) and ventilation in all areas where painting operations and inspections are in progress.
14. Install piping markers only after all painting and finish work has been completed and cured.

D. Protection:
   1. Cover or otherwise protect finished Work of other trades and surfaces not being painted concurrently or not to be painted.
   2. During surface preparation and painting, the facility shall remain in operation. Employ procedures that prevent contamination of the process or cause facility shutdown.
   3. Coordinate and schedule surface preparation and painting to avoid exposing employees and others not involved with surface preparation and painting. Provide required personnel safety equipment in compliance with the requirements of governing authorities having jurisdiction.
   4. Submit protection procedures to be employed. Do not begin surface preparation and painting Work in any area until ENGINEER approves protection techniques proposed.
   5. Provide fire extinguishers and post caution signs warning against smoking and open flame when working with flammable materials.

E. Spent abrasive containing lead and/or chromate paint resulting from the blasting of the "affected surfaces" is classified as a hazardous waste. "Spent abrasive" shall be understood to mean the abrasive generated during the blasting operation, including the spent water imposed over the abrasive flow, paint residue and any other debris.

F. Care shall be exercised to prevent spent abrasive, water or dust from falling on surrounding buildings, unprotected vegetation, walkways, soils, structures and equipment by covering these areas with non-tearing tarps. Spent abrasive collecting on the ground shall be vacuumed regularly to prevent it from becoming windblown. The site shall at all times be kept as clean as possible. At the end of the Work day, all spent abrasive shall be thoroughly vacuumed and the site left with a neat appearance.

G. Spent abrasive resulting from the blasting of the "affected surfaces" shall be captured. Non-tearing tarps or plastic sheathing, platforms, partial or total enclosures, temporary barriers or structures, or similar containment methods may be employed for this purpose. These methods must be reviewed by the ENGINEER prior to start of the Work. Provide

a detailed procedure describing the proposed blast cleaning operation, abrasive capture and containment techniques, and safety measures to avoid the contamination of the natural environment or surrounding structures.

H. Spent abrasive resulting from the blasting of the "affected surfaces" shall be collected and legally disposed of by the CONTRACTOR in a legal and responsible manner. Such disposal shall also be in conformance with all applicable codes, ordinances and regulations for hazardous waste disposal. All other waste, including spent abrasive generated by the blasting of non-affected surfaces, shall be disposed by the CONTRACTOR.

I. All reasonable care shall be taken to protect against paint splatter and overspray. Responsibility for any damage incurred to surrounding property resulting from this work belongs to the CONTRACTOR.

J. Signs shall be posted, as required, to alert the public of any risks associated with sandblasting debris, painting overspray, etc. All efforts shall be made to prevent debris from becoming windblown.

K. Obtain all permits required to perform the Work.

L. Spent water, resulting from the cleaning operation of "affected surfaces" due to wet sandblasting, may contain hazardous particulates, shall be disposed by the CONTRACTOR.

PART 2 - PRODUCTS

2.1 MANUFACTURER

A. Specification basis of design is Tnemec

B. Approved Equals: Subject to meeting these specifications requirements and system approval the following manufacturers may be acceptable.

C. Submit system proposed as “Equal” for review and approval or revision as required by the ENFINEER:
1. Sherwin Williams
2. Carboline
3. Ameron/PPG
4. International

2.2 PAINTING SYSTEMS

A. New and Existing Cast-In-Place Concrete Walls (except walls within the height of chemical containment dike wall areas), Columns, Underside of Roof Slabs and Beams, Architectural Precast Concrete; Non-Submerged, Interior. (LEED Compliant through Version 3.0)

B. Severe Exposure
   1. Surfacer/Filler (Epoxy Modified Cementitious Mortar)
      a. Tnemec Series 218 MortarClad; 1 parge coat trowel applied; nominal 1/16 inch minimum DFT (actual DFT to depend on the depth of the profile in the concrete after abrasive blasting.)
   2. Primer (Modified Polyamine Epoxy Penetrating Epoxy)
      a. Tnemec Series 201 EpoxoPrime; 1 coat; 6-8 mils DFT
   3. Base Coats (Fiberglass Reinforced Polyamine Epoxy)
      a. Tnemec Series 270 Stranlok; 2 coats; 25-40 mils Total DFT
   4. Finish Coat (Modified Polyamine Epoxy)
      a. Tnemec Series 280 Tnemec Glaze; 1 coat; 6-8 mils DFT

C. Moderate Exposure
   1. Surfacer/Filler (Epoxy Modified Cementitious Mortar)
      a. Coating 1. Tnemec Series 218 MortarClad; 1 parge coat trowel applied; nominal 1/16 inch minimum DFT (actual DFT to depend on the depth of the profile in the concrete after abrasive blasting.)
   2. Primer (Polyamidoamine Epoxy)
      a. Tnemec Series L69 Hi-Build Epoxoline II; 1 coat; 4-6 mils DFT
   3. Finish Coat (Polyamidoamine Epoxy)
      a. Tnemec Series L69 Hi-Build Epoxoline II; 1 coat; 4-6 mils DFT

D. New and Existing Cast-In-Place Concrete associated with all Primary Settling Tanks and Influent Channels; Non-submerged, Intermittently Submerged and Submerged, Interior and Exterior:
   1. Concrete surfaces within the area of the Primary Settling Tanks and Influent Channels, and extending to top of Primary Settling Tank horizontal walkway surface, including but not necessarily limited to, troughs, walls, beams, columns, undersides of walkways and other locations which may be shown on the Drawings.
   2. Patch /Filler/ Surfacer (Epoxy Modified Cementitious Mortar)
      a. Tnemec Series 218 MortarClad; Trowel applied as needed
   3. Finish Coat (Fiber-Reinforced Modified Polyamine Epoxy)
      a. Tnemec Series 436 Perma-Shield FR; 1 coat; 60 mils DFT minimum

E. To the extend shown on the DRAWINGS, new and existing cast-in-place concrete floors, equipment pads, sumps, trenches, walls, columns and all other cast-in-place concrete within chemical containment areas. Comply with manufacturer's current written recommendations for mixing, curing and application.
   1. Patch /Filler/ Surfacer (Epoxy Modified Cementitious Mortar)
      a. Tnemec Series 218 MortarClad; Trowel applied as needed
   2. Primer (Modified Novolac Polyamine Epoxy)
      a. Tnemec Series 239SC Chembloc RCK (Resin Containment Kit); 1 coat; 4-12 mils DFT
   3. Base Coat (Modified Novolac Polyamine Epoxy Mortar)

a. Tnemec Series 239SC Chembloc (with Part C Aggregate) MCK (Mortar Containment Kit); 1 coat; 60-80 mils DFT

4. Reinforcement:
   a. Tnemec Series S211-0215; ¾ ounce chopped strand fiberglass mat embedded into the Series 239SC Epoxy Mortar base coat
5. Saturant Coat (Modified Novolac Polyamine Epoxy)
   a. Tnemec Series 239SC Chembloc RCK; 1 coat; 8-12 mils DFT
6. Finish Coats (Polyamine Novolac Epoxy)
   a. Tnemec Series 282 Tnemec-Glaze; 2 coats; 4-8 mils DFT per coat (vertical); 6-12 mils DFT per coat (horizontal)
7. Finish Coating System: Total DFT: 100-125 mils
8. Finish Coat: Aliphatic Polyester Polyurethane CRU (Chemical Resistant Urethane) UV Resistant
   a. Tnemec Series 290 CRU; 1 coat; 2-3 mils DFT (For exterior exposure (considered sacrificial); do not use in trenches, sumps or interior exposure.)

F. New and Existing Ferrous Metals, Structural Steel (not protected by sprayed fireproofing), Miscellaneous Ferrous Metals, Exterior Surfaces of Valves, Exterior Surfaces of Ferrous Piping, Above ground Ductile-Iron Piping and Exterior Surfaces of all Ferrous Piping (both exposed and to be later covered with insulation); Non-submerged, Interior : (LEED Compliant through Version 3.0)
   1. Primer (Polyamidoamine Epoxy *)
      a. Tnemec Series L69 Hi-Build Epoxoline II; 1 coat; 4-6 mils DFT
   2. Finish Coat (Polyamidoamine Epoxy)
      a. Tnemec Series L69 Hi-Build Epoxoline II; 1 coat; 4-6 mils DFT

G. New and Existing Ferrous Metals, Non-Ferrous Metals, Fiberglass and Galvanized Metals; Non-Submerged, Exterior:
   1. Primer (Polyamidoamine Epoxy*)
      a. Tnemec Series N69 Hi-Build Epoxoline II; 1 coat; 4-6 mils DFT
   2. Intermediate Coat (Polyamidoamine Epoxy)
      a. Tnemec Series N69 Hi-Build Epoxoline II; 1 coat; 4-6 mils DFT
   3. Finish Coat (Aliphatic Acrylic Polyurethane with UV Absorbers)
      a. Tnemec Series 1075U Endura-Shield II; 1 coat; 2.5-3.5 mils DFT

H. New and Existing Galvanized Metal, Fiberglass and Non-Ferrous Metal; Non-submerged, Interior: (LEED Compliant through Version 3.0)
   1. Primer (Polyamidoamine Epoxy*)
      a. Tnemec Series L69 Hi-Build Epoxoline II; 1 coat; 4-6 mils DFT
   2. Finish Coat (Polyamidoamine Epoxy)
      a. Tnemec Series L69 Hi-Build Epoxoline II; 1 coat; 4-6 mils DFT

I. New and Existing Aluminum in Contact with Dissimilar Materials:
   1. Primer (Polyamidoamine Epoxy)
      a. Tnemec Series N69 Hi-Build Epoxoline II; 1 coat; 4-6 mils DFT

2. Finish Coat (Polyamidoamine Epoxy)
   a. Tnemec Series N69 Hi-Build Epoxoline II; 1 coat; 4-6 mils DFT

J. New and Existing Pipe and Duct Insulation, Cloth, Paper and Canvas Jacketed; Non-submerged, Interior: (LEED Compliant through Version 3.0)
1. Prime Coat (Self-crosslinking Hydrophobic Acrylic)
   a. Tnemec Series 115 Uni-Bond DF; 1 coat; 2-4 mils DFT
2. Finish Coats (HDP Acrylic Polymer)
   a. Tnemec Series 1029 Enduratone; 2 coats; 2-3 mils DFT per coat

K. New and Existing PVC and CPVC Piping and Fiberglass Insulation Covering; Non-submerged, Interior: (LEED Compliant through Version 3.0)
1. Prime Coat (Self-crosslinking Hydrophobic Acrylic)
   a. Tnemec Series 115 Uni-Bond DF; 1 coat; 2-4 mils DFT
2. Finish Coat: (HDP Acrylic Polymer)
   a. Tnemec Series 1029 Enduratone; 1 coat; 2-3 mils DFT

L. New and Existing Exterior Surfaces of Steel Pipe; Buried Exterior:
1. Primer (Polyamidoamine Epoxy)
   a. Tnemec Series N69 Hi-Build Epoxoline II; 1 coat; 6-8 mils DFT
2 Finish Coat (Polyamidoamine Epoxy)
   a. Tnemec Series N69 Hi-Build Epoxoline II; 1 coat; 6-8 mils DFT

M. Where it is determined that abrasive blasting surface preparation is not feasible use Tnemec Series 135 Chembuild as the prime coat.

2.3 SUBSTITUTIONS

A. No products that decrease the film thickness, the surface preparation, VOC's, solids by volume or the generic type of coating specified shall be considered. Approved manufacturers shall furnish the same color selection as the manufacturers specified, including accent colors and custom colors in all coating systems, and shall document satisfactory performance of their coating system For at least three municipal lift stations or municipal wastewater treatment plants that have been in service at least five years each.

2.4 PIPING MARKERS

A. General:
1. For pipes over 3/4-inch outside diameter: Provide painted pipe markers.
2. For pipes under 3/4-inch outside diameter: Provide aluminum tags, totally compatible with service conditions, 1-1/2-inch diameter, with depressed 1/4-inch high black filled letters Above 1/2-inch high black filled numbers.
3. Each marker shall consist of at least one legend descriptive of the function of the pipe and a directional arrow.
4. The size of lettering and marker shall conform to ANSI A13.1.

5. Location of Markers:
   a. Adjacent to each valve and "T" connection.
   b. At each branch and riser takeoff.
   c. At each pipe passage through a wall, floor and ceiling.
   d. On all horizontal and vertical pipe runs at 25-foot intervals.

PART 3 - EXECUTION

3.1 INSPECTION

A. Examine the areas and conditions under which painting Work is to be performed and notify ENGINEER, in writing, of conditions detrimental to the proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions have been corrected in a manner acceptable to ENGINEER.

B. Do not paint over dirt, rust, scale, grease, moisture, scuffed surfaces, or conditions otherwise detrimental to the formation of a durable paint film capable of performing in accordance with claims made in manufacturer's product literature for the surfaces and conditions encountered. Do not paint over “UL” or similar labels, including mechanical and electrical Manufacturer nameplates.

C. Do not paint over existing paint where there is no assurance that existing paint will provide an acceptable surface for the long-term adherence and durability of painting systems specified or where the manufacturer requires removal of all existing paint in order to recommend the use of the specified painting system.

D. Provide lighting for all work areas to be inspected as prescribed in SSPC Guide 12. No coating inspections will be conducted until the minimum lighting requirements for inspection is provided.

E. Assure that all surfaces and areas to be inspected will be clean and ready for inspection so the coating and/or lining system can be immediately applied. No inspections will be conducted if areas and/or surfaces have dust and debris floating in the air and/or covering the substrates to be inspected.

F. All expenses due to delays, extra coating inspections etc is the sole responsibly of the CONTRACTOR.

3.2 SURFACE PREPARATION

A. General:
   1. Prepare all substrates new or existing according to the coating manufacturers’ current written guidelines for the submitted coating system and its intended service environment.

2. Use abrasive blasting equipment of conventional air, force-feed, or pressure type. Maintain a minimum pressure of 650 kPa 95 psig at nozzle. Confirm that air supply for abrasive blasting is free of oil and moisture when tested according to ASTM D 4285. Test air quality at each startup, but in no case less often than every five operating hours.
3. Provide lighting for all work areas as prescribed in SSPC Guide 12.
4. Prior to performing any testing, i.e soluble salts, adhesion, moisture content or vapor, alkalinity etc all principle parties shall agree upon in writing methods of testing, quantity of testing, acceptable results, and the proper course of action that will be taken in case the acceptable limits are not or cannot be met. Excessive moisture, or other conditions, may impact the Project Schedule.
5. Prior to any surface preparation covered in this section, all surfaces should meet the acceptable conditions required.
    a. Inspect all surfaces for oil and/or grease contamination using two or more of the following inspection techniques. Reject oil and/or grease contaminated surfaces, clean [using a water based pH neutral degreaser]in accordance with SSPC SP 1, and recheck for contamination until surfaces are free of oil and grease.
        1) Visual Inspection
        2) Water Break Test
        3) Black Light Test
        4) Cloth Rub Test
    b. Water Break Test - Spray atomized mist of distilled water onto surface, and observe for water beading. If water "wets" surface rather than beading up, surface can be considered free of oil or grease contamination. Beading of water (water forms droplets) is evidence of oil or grease contamination.
    c. Black Light Test - Inspect surfaces for oil and grease contamination using the light specified in the paragraph Black Light. Use light no more than 12 inches from surface unless testing indicates that the specific oil or grease found in tank fluoresce at a greater distance. Use light in tank that is completely sealed from light infiltration, under a hood, or at night. Any fluorescing on steel surfaces is an indication of petroleum oil/grease contamination. Use either Water Break Test or Cloth Rub Test to confirm both contaminated and non-contaminated areas detected by Black Light Test. The Black Light Test may not be used during inspection of prepared surfaces for oil and grease contamination unless proven to fluoresce the oil and/or grease found in the specific tank and documented during testing prior to abrasive blasting. Generally, only petroleum oil/grease will fluoresce, however, some may not fluoresce sufficiently to be recognized and other methods, such as the Water Break Test or Cloth Rub Test, must be used to confirm findings of the Black Light Test.
    d. Cloth Rub Test - Rub a clean, white, lint free, cotton cloth onto surface and observe for discoloration. To confirm oil or grease contamination in lightly stained areas, a non-staining solvent may be used to aid in oil or grease extraction. Any visible discoloration is evidence of oil or grease contamination.
6. Remove all hardware, hardware accessories, machined surfaces, plates, lighting fixtures, and similar items already in-place and that does not require field painting, or

provide effective surface-applied protection prior to surface preparation and painting operations.

7. Remove, as necessary, items, which must be field-painted where adjacent surfaces cannot be completely protected from splatter or overspray. Following completion of painting of each space or area, the removed items shall be reinstalled by workers skilled in the trades involved. Surfaces to be painted must be clean, dry and sound before applying any painting system components. Should any surface be found in an unsatisfactory condition, remediate by the best means feasible to provide a acceptable coating condition.
8. Coating products shall not be applied until the ENGINEER has inspected the materials and the coating manufacturer's technical representative has instructed CONTRACTOR and ENGINEER in the surface preparation, mixing and application of each coating.

B. Cast In Place Concrete. Precast Concrete and other Masonry Substrates

1. Test for moisture content of concrete surfaces before commencement of painting Work. There are many tests for moisture in concrete such as ASTM D 4263, ASTM F 1869 or ASTM F 2170. Provide from the submitted coating manufacturer in writing as to which standard they want used and what results must be obtained for satisfactory compliance. Report results to ENGINEER before starting Work.
2. Verify that the pH levels, of the cleaned concrete surfaces to be coated, are 10 to 12 or within the coating manufacturers' current written acceptable range. The pH of the concrete substrate will be measured using pH indicating papers. The pH testing is to be performed once every 50 square feet (5 square meters). Acceptable pH values can be measured using color indicating pH paper with readable color calibrations and a scale at whole numbers (minimum). Use Hydrion Insta-Check Jumbo 1-12, or equal. The paper shall be touched to the surface once using moderate gloved finger pressure. The surface shall not be wiped or moved laterally to disturb the surface during pH testing. Following the one touch, lift the paper vertically to not "wipe" the surface. Compare the color indicated with the scale provided and record the pH. Spot check any areas that may be questionable with phenolphthalein solution. Where paint system is used to provide chemical containment barrier protection, repair cracks and expansion joints in concrete and provide 2-inch radius cove base fillets at all equipment pads and containment walls as part of the complete chemical containment paint system Work. Use materials and techniques recommended by the specified Manufacturer.
3. Remove all cast-in-place concrete fins, projections, tie wire, nails and other surface irregularities, which would protrude above the level of finished intermediate fillers and surfacers by chipping and scarification by mechanical abrasion.
4. Using specified filler and surfacer, patch all cast-in-place concrete and precast concrete surfaces as required to completely fill surface air holes and honeycombing. Level all protrusions and grind filler and surfacing compounds smooth and level with adjacent surfaces.
5. Where concrete masonry unit block filler is specified, spot patch holes and cracks with a putty knife using specified block filler to provide smooth finish for large sur-

faces coating materials can be applied by airless spray and backroll uniformly using a roller with a synthetic nap cover. While the coating material; is still wet a rubber squeegee can be used to provide a smooth finish.

C. Ferrous Metals:

1. Test surfaces for soluble salts, and wash as required, prior to any surface preparation. This phase is recommended since pre-preparation testing and washing are generally more advantageous than attempting to remove soluble salt contamination after abrasive blasting. Effective removal of soluble salts will require the removal of any barrier to the steel surface, including rust. This procedure may require combinations of wet abrasive blasting, high pressure water washing, and cleaning using a solution of water washing and soluble salts remover. The soluble salts remover shall be a acidic, biodegradable, nontoxic, noncorrosive, and after application, will not interfere with primer adhesion. Delays between testing and preparation, or testing and coating application, may allow for the formation of new contamination. Use clean potable water, or clean potable water modified with soluble salt remover, for all washing or wet abrasive blasting. Test methods and equipment used in this phase are selected at the Contractor's discretion.
2. Verify that coating manufacturer recommended anchor profiles have been achieved on prepared surfaces using the submitted coatings current guidelines for its intended service environment. Report profiles to ENGINEER using Test Method B or C in compliance with ASTM D 4417.
3. All surface imperfections (e.g., sharp fins, sharp edges, weld spatter, burning slag, scabs, and slivers) existing or new shall be removed from submerged or non-submerged ferrous metal surfaces. All edges and corners shall be ground to provide a smooth 1/16” radius. New ferrous metal surface imperfections are the responsibility of the manufacturer. Acceptance of the substrate without having these imperfections being corrected becomes the sole responsibility of the CONTRACTOR. Surface imperfections of previously coated ferrous metal surfaces that are being re-coated are the responsibility of the CONTRACTOR to remove or have re-moved.
4. Submerged or non-submerged ferrous surfaces including structural steel and miscellaneous metal to be shop-primed shall be prepared according to the coating manufacturers current written guidelines for the submitted coating system and its intended service environment.
5. All shop primed items shall be inspected in the shop by an independent NACE CCI. Any shop applied coated pieces that do not or cannot provide documents for Q/C inspection will be re-prepared and re-coated in the field. The shop coating applicator will be solely responsibility for all financial burdens associated with this remediation.
6. Touchup shop applied prime coats which have damaged or have bare areas, according to SSPC-SP11, (Power Tool Cleaning to Bare Metal) at the time of painting system application, SSPC VIS 3 can be used as a comparison, Tightly adhering coating surrounding the bare metal shall be feather edged a minimum of 1 inch back to provide a clean, dry, sound and smooth transition from bare metal to remaining coating.

7. Remove all surface imperfections (e.g., sharp fins, sharp edges, weld spatter, burning slag, scabs, slivers) using SSPC-SP2 (Hand Tool Cleaning) and/or SSPC-SP3 (Power Tool Cleaning) before full surface preparation operations begin.
8. Remove all rust and contamination on existing ferrous metals to sound surfaces by power tool cleaning complying with SSPC SP11 to provide a surface profile of not less than one mil.
9. Non-Ferrous Metal Surfaces: Prepare all substrates new or existing according to the coating manufacturers' current written guidelines for the submitted coating system and its intended service environment.

D. Galvanized (Zinc-Coated) Surfaces: Prepare all substrates new or existing according to the coating manufacturers' current written guidelines for the submitted coating system and its intended service environment.

E. CPVC Piping and Fiberglass: Prepare all substrates new or existing according to the coating manufacturers' current written guidelines for the submitted coating system and its intended service environment.

F. Covering on Pipe Insulation:
1. Remove all oil and surface contaminants as recommended by manufacturer for surface and application required.
2. Do not cut or damage the insulation in any way.

G. Gypsum Wallboard and Plaster:
1. Patch, sand and seal all rough spots before apply prime coat. Remove all dust and other contaminants prior to painting.
2. Touch-up all suction spots and hot spots with primer before application of finish coats.

H. Wood:
1. Clean wood surfaces to be painted of all dirt, oil, or other foreign substances with scrapers, mineral spirits, and sandpaper, as required. Sandpaper smooth those finished surfaces exposed to view, and dust off.
2. Prime, stain, or seal wood required to be site painted immediately upon delivery to job. Prime edges, ends, faces, undersides, and backsides of such wood, including cabinets, counters, cases, paneling and similar items.
3. Back prime paneling or interior partitions only where masonry, plaster, or other wet wall construction occurs on backside.
4. Seal tops, bottoms and cutouts of wood doors with a heavy coat of sealer as recommended by the door manufacturer immediately upon delivery to site.
5. Scrape and clean small, dry, seasoned knots and apply a thin coat of white shellac or other recommended knot sealer, before application of the priming coat.
6. After priming, fill holes and imperfections in finish surfaces with putty or plastic wood filler as recommended by manufacturer, sandpaper smooth when dried and dust off.

3.3 MATERIALS PREPARATION

A. General:
   1. Mix and prepare painting materials in strict accordance with the coating manufacturer's current product literature.
   2. Only use coating materials of the submitted coating manufacturer. Do not mix any painting materials produced by different manufacturers.
   3. Only use thinners when required in the Work and that are provided by the coating manufacturer for the submitted coating system. Do not use any thinners not documented on its current product data sheet or outside its recommended guidelines.
   4. Any deviation of mixing procedures must be approved in writing by the ENGINEER before any procedural change will be allowed.

B. Tinting:
   1. Tint each undercoat a lighter shade to facilitate identification of each coat of multiple coat coating and/or lining systems.
   2. Tint undercoats to match the color of the finish coat of paint, but provide sufficient difference in shade of undercoats to distinguish each separate coat. Provide a code number to identify material tinted by the manufacturer.

C. Mixing:
   1. For those products requiring constant agitation, use methods in compliance with manufacturer's product literature, to prevent settling during paint application.
   2. Mix only in containers placed in suitably sized nonferrous or oxide resistant metal pans to protect concrete floors from splashes or spills. Provide for cleanup and for any damage associated from splash and/or spills.
   3. Mix and apply paint only in containers bearing accurate product name of material being mixed, or applied.
   4. Stir all materials before application to produce a mixture of uniform density, and as required during the application of the materials. Do not stir any film, which may form on the surface into the material. Remove the film and, if necessary, strain the material before using.
   5. Strain products requiring such mixing procedures. After adjusting mixer speed to break up lumps and after components are thoroughly blended, strain through 35 to 50 mesh screen before application.

3.4 GENERAL APPLICATION REQUIREMENTS

A. General:
   1. Thin, mix and apply coatings by brush, roller, or spray in strict accordance with manufacturer’s installation instructions.
      a. Application equipment must be inspected and approved in writing by coating manufacturer.
   2. Temperature and weather conditions:

a. Do not paint surfaces when surface temperature is below 50F unless product has been formulated specifically for low temperature application or approved in writing by Engineer and paint manufacturer's authorized representative.
b. Air and Surface Temperatures: Prepare surfaces, then apply and cure coatings within air and surface temperatures minimum and maximum range according to the Manufacturer's current instructions.
c. Avoid painting surfaces exposed to hot sun.
d. Do not paint on damp surfaces.

3. Immediately after any surface has been inspected and accepted, coatings must be applied, i.e. concrete, structural steel and miscellaneous steel prime coat.
   a. Finish coats shall be applied in the field.
   b. Prime coat referred to here is prime coat as indicated in this Specification. Structural and miscellaneous steel prime coating applied in factory (shop) as part of Fabricator's standard rust inhibiting and protection coating is not acceptable as replacement for specified prime coating.
4. Provide complete coverage to dry film thickness range specified.
   a. All paint systems are "to cover." In situations of discrepancy between manufacturer's square footage coverage rates and mil thickness, mil thickness requirements govern. When color or undercoats show through, apply additional coats until paint film is of uniform finish and color.
5. If so directed by Engineer, do not apply consecutive coats until Engineer has had an opportunity to observe and approve previous coats.
6. Use alternating colors to separate and distinguish the applied coatings.
7. Apply materials under adequate illumination as required under SSPC-Guide 12 Guide for Illumination of Industrial Painting Projects
8. Evenly spread to provide full, smooth coverage. All paint is to be applied in a continuous, monolithic and pinhole free manner.
9. Stripe coat (each coat) with a brush prior before full application. Stripe coats should be applied to edges, corners, crevices, joints, and other difficult to work areas.
10. Avoid degradation and contamination of blasted surfaces and avoid inter-coat contaminate:
    a. Clean contaminated surfaces before applying next coat
    b. Final coat shall be contaminate free. Remediated areas shall have the same color and gloss appearance as the surrounding painted area. A patchy appearance is not acceptable. Re-coat until appearance is acceptable by the ENGINEER at no additional cost to the owner.
11. Smooth out runs or sags immediately, or remove and re-coat entire surface.
12. Allow preceding coats to dry before recoating.
    a. Re-coat within time limits specified by coating manufacturer.
    b. If re-coat time limits have expired re-prepare surface according to the coating manufacturer's current printed recommendations.
13. Allow coated surfaces to cure according to coating manufacturers written recommendations prior to allowing traffic or other work to proceed.
14. Coat all aluminum in contact with dissimilar materials.

15. When coating rough surfaces which cannot be back rolled sufficiently, hand brush coating to work into all recesses.
16. Spray, backroll, spray concrete surfaces if paint coatings are spray applied.

B. Prime Coat Application:
   1. Prime all surfaces indicated to be painted. Apply prime coat according coating manufacturer's written instructions.
   2. Ensure new coatings applied over existing coatings are compatible.
      a. Employ services of qualified independent NACE CCI or a coating manufacturer's qualified technical representative
         1) Certify thru material data sheets.
         2) Perform test patch.
         3) Provide written documentation of acceptance or non-acceptance of adhesion and compatibility.
      b. If field-applied coating is found to be not compatible, require the coating manufacturer's technical representative to recommend, in writing, product to be used as barrier coat, thickness to be applied, surface preparation and method of application.
      c. At Contractor's option, coatings may be removed, surface re-prepared and new coating applied using appropriate paint system.
   3. All damage to surface as result of coating removal shall be repaired to original condition or better at no additional cost to OWNER.
   4. Prepare and prime ferrous metals embedded in concrete to minimum of 1inch below exposed surfaces in accordance with coating manufacturers recommendations.
   5. Apply zinc-rich primers while under continuous agitation.
   6. Ensure abrasive blasting operation does not result in embedment of abrasive particles in paint film.
   7. All abrasive shall be vacuumed cleaned or swept and vacuum cleaned.
   8. Brush or spray bolts, welds, edges crevices corners, edges and other difficult access areas with primer prior to primer application over entire surface.
   9. Touch up damaged primer coats prior to applying finish coats. Restore primed surface equal to surface before damage.

C. Finish Coat Application:
   1. Apply finish coats according to coating manufacturer's written instructions.
   2. Touch up damaged finish coats using same application method and same material specified for finish coat. Prepare damaged area in accordance with Article 3.4.

3.5 REPAIRS

A. All repairs and corrective work will be done according to the coating manufacturers provide written recommendations. No repairs will be completed without the coating manufacturers written recommendations.

3.6 FIELD QUALITY CONTROL

A. Prior to initiating painting Work (if required), perform adhesion tests on existing coated surfaces, bare concrete substrates or newly/existing patched concrete to be painted. The following test methods are suggested.
   1. ASTM D4541 - Pull-Off Strength of Coatings Using Portable AdhesionTesters
   2. ASTM D7234 - Pull-Off Adhesion Strength of Coatings on Concrete Using Portable Pull-Off Adhesion Testers
   3. ASTM C1583/C1583M - Tensile Strength of Concrete Surfaces and the Bond Strength or Tensile Strength of Concrete Repair and Overlay Materials by Direct Tension (Pull-off Method)

B. Consult with the coating manufacturer to determine if these or other methods are acceptable. Provide written test methods and qualifications for acceptance to ENGINEER. The number and location of tests shall be sufficient for CONTRACTOR to determine the condition of existing coatings and the suitability of existing coatings to remain to provide an acceptable substrate for new coatings. Submit testing plan prior to testing and provide ENGINEER a copy of adhesion test results.

C. Painting Records:
   1. Maintain permanent written records of daily Q/C responsibilities.
   2. Verify and record that the coatings and other materials are as specified (i.e., manufacturer, product name & product batch dates).
   3. Verify and record condition of coatings and material along with their storage procedures
   4. Verify and record surface preparation and application of coatings are as specified.
   5. Verify and record coating mixing and thinning procedures, i.e. batch dates, amount mixed, material temperatures, induction time etc.
   6. Verify and record application procedures.
   7. Verify and record environmental conditions one half hour before work starting, then every 2 hours afterwards and once upon completion of work that day. Environmental readings must be obtained in the area that the work is taken place. Environmental readings shall not be obtained from computers, TV or cell phone apps. Readings shall be immediately taken should a sudden change in the climate be observed. Record results using sample forms or similar approved forms.
   8. Verify and record WFT and DFT of each coat of the coating system are as specified using new wet film gauges and certified dry film thickness gauges. Dry film thickness readings shall be done according to SSPC-PA 2 (Level 3)

D. Independent NACE Third Party Inspection Responsibilities (Full Time):
   1. Maintain permanent written records of daily Q/C responsibilities.
   2. Verify and record that the coatings and other materials are as specified (i.e., manufacturer, product name & product batch dates).
   3. Verify and record condition of coatings and material along with their storage procedures.

4. Verify and record environmental conditions one half hour before work starting, then every 2 hours afterwards and once upon completion of work that day. Environmental readings must be obtained in the area that the work is taken place. Readings shall not be obtained from computers, TV or cell phone apps. Environmental readings shall be immediately taken should a sudden change in the climate be observed. Record results using sample forms or similar approved forms.
5. Surface Preparation Inspection - Verify and record that the specified surface preparation meets or exceeds specified cleanliness standard and surface profile. Check for characteristics or defects that would adversely affect performance or appearance of coating systems.
6. Verify and record coating mixing and thinning procedures, i.e. batch dates, amount mixed, material temperatures, induction time etc.
7. Verify and record application procedures.
8. Coating Inspection - Verify and record the DFT readings of each coat. Check the applied coating film for characteristics or defects that would adversely affect performance or appearance of coating systems, i.e. runs, sags skippers, inconsistent / poor coverage.
9. Dry film thickness readings of ferrous and non-ferrous substrates shall be done in accordance with SSPC-PA 2 (Level 3).
10. Dry film thickness readings of concrete, wood, CPVC, drywall etc will be done according to agreed procedures of all parties.
11. Dry film thickness reading equipment to be used must be certified and still within certification during the inspection process.
    a. Ferrous and Non-Ferrous substrates - Type 1or Type 2 dry film thickness gauges, manufactured by Elcometer, Defelsko or equal.
    b. Concrete, wood, CPVC, drywall - Defelsko Posi-Tector 200 using the correct probe for the substrate and thickness to be verified.
12. Check for discontinuities on concrete and/or steel immersion surfaces using holiday detector (NACE SP0-188). Any discontinuities located shall be corrected in according to with the coating manufacturer’s most current written recommendations/guidelines. All corrected discontinuities shall be re-tested according to (NACE SP0-188) until compliant.

E. Verification/ Compliance of Inspection Instruments
   1. Only use inspection equipment in good working order and has been certified by the equipment manufacturer on a yearly basis minimum. Certificates of calibration must be provided to the ENGINEER upon request.

3.7 PROTECTION

A. Provide "Wet Paint" signs as required to protect newly painted finishes. Protect surfaces of coating systems from damage from any possible surrounding activity.

B. Remove all temporary protective wrappings provided for protection of this Work and the work of other contractors after completion of painting operations.

3.8 ADJUSTMENT & CLEANUP

A. Correct all damages to the work of other trades by cleaning, repairing or replacing, and repainting, as acceptable to ENGINEER.

B. During the progress of the Work, remove from the site all discarded paint materials, rubbish, cans and rags at the end of each work day.

C. Upon completion of painting, clean all paint spattered surfaces. Remove spattered paint by proper methods of washing and scraping, using care not to scratch or otherwise damage finished surfaces. Any damage associated with the cleaning and removal process is the CONTRACTORS responsibility.

D. At the completion of Work of other trades, touchup and restore all damaged or defaced painted surfaces as determined by ENGINEER.

3.9 WARRANTY INSPECTION

A. The OWNER or OWNERS REPERSENTATIVE will conduct a warranty inspection during the eleventh (11th) month following completion of all coating work. All defective work shall be repaired by the CONTRACTOR in strict accordance with coating manufacturer's instructions, this Specification, and to satisfaction of OWNER and/or the OWNER'S REPRESENTATIVE.

B. Entire interior coating system shall be visually inspected. All defective coating, as well as damaged and rusting spots shall be satisfactorily repaired by and at no cost to the OWNER.

C. Coating Manufacturer's Representative: Shall be present, at no cost to the OWNER, during inspection of work to assist with assessment of condition of interior and exterior coating and make recommendations for methods of repair of coating systems as may be required.

D. Inspection Report: Provide an inspection report covering first anniversary inspection, setting forth number and type of failures observed and percentage of surface area where failures have occurred.

E. Schedule: Upon completion of inspection and receipt of an Inspection Report as noted herein, The OWNER shall establish a date to proceed with remedial work. Any delay to meet schedule established by OWNER shall constitute breach of this Contract and the OWNER may proceed to have defects remedied, with costs involved paid by the CONTRACTOR.

F. Remedial Work: Any location where coating has peeled, bubbled, or cracked and any location where rusting is evident shall be considered to be a failure of coating system. CONTRACTOR shall make repairs at all points where failures are observed by removing deteriorated coating, cleaning surface, and recoating with same coating system. If area of failure exceeds twenty-five percent (25%) of total coated surface, entire coating system may be required to be removed and recoated in accordance with original Specification.

G. Costs: All costs for repair shall be borne by CONTRACTOR.

H. Repairs shall be warranted for an additional period of one (1) year.

SAMPLE DAILY LOG

Engineer:	**GC:**	**Paint Contractor:**
Eng Contact:	**GC Contact:**	**Supervisor:**
Structure Description:		**Date:**
Specification:	**Project:**	

Hold Point/ Inspection Item	**Performed by Contractor's QC**			**Status**		**Action Taken to Resolve UNSAT Conditions**
	YES	**NO**	**N/A**	**SAT**	**UNSAT**	
Adequate access & lighting provided						
Protective coverings in place						
SP-1 performed and grease, oil, & contamination re-moved						
Sharp edges, fins, slivers removed						
Removal of pack rust						
Ambient conditions						
Nozzle pressure						
Compressed air cleanliness						
Abrasive type & cleanliness						
Surface cleanliness						
Surface profile						
Soluble salt testing						
Soluble salt remediation						

Hold Point/ Inspection Item	Performed by Contractor's QC			Status		Action Needed to Resolve UNSAT Conditions
	YES	NO	N/A	SAT	UNSAT	
Coating mixing						
Coating application						
Intercoat cleanliness achieved						
Recoat times observed						
Stripe coat applied						
Caulking applied						
Wet film thickness measurements						
Dry film thickness measurements						
Visual appearance						
Repairs to damaged coatings performed						

Ambient Conditions								
Location	Time	RH%	Air Temp	Surface Temp	Dew Point	Surface/ Dew Pt +/-	SAT	UNSAT

QC Testing Performed	N/A	N/P	Location(s)	Specified	Actual	SAT	UNSAT
Compressed Air Cleanliness							
Surface Preparation (Cleanliness)							
Surface Profile							
Soluble Salt Contamination SCAT Chlor*Test Brescle Kitagawa Quantab Other:							
Wet Film Thickness							
Dry Film Thickness							

Coating Materials									
				Component A		Component B		Thinner	
Coating Type	Location Applied	Mix No.	Qty Mixed	Expiration Date (Shelf Life)	Batch No.	Expiration Date (Shelf Life)	Batch No.	Type/ Name	Batch No.

Coating Material & Mixing Data										
Mix No.	% Thinner Added		Time of Mix	Mixed Coating Temp	Induction Time (SP)	Pot Life (SP)	Mix		Time from surface preparation/ previous coat to application	Coating Start/Stop Time
	Spec	Actual					SAT	UNSAT		

++ END OF SECTION ++

SECTION 09985

NOVOLAC EPOXY LINING SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, tools, equipment and incidentals as shown, specified and required to furnish, install and place into satisfactory service the Novolac epoxy lining corrosion protection system. The Work also includes:
      a. Providing openings in the Novolac epoxy lining corrosion protection system to accommodate the Work under this and other Sections, and build into the Novolac epoxy lining corrosion protection system all items such as sleeves, anchor bolts, inserts and all other items to be embedded in, or inserted through, the Novolac epoxy lining corrosion protection system for which placement is not specifically provided under other Sections.
      b. All systems shall include scarification, acid etching and other substrate preparations, bond coats, reinforcements, underlayment fills, moisture barrier coatings, binder coats, top coats, sealants and other components and system accessories recommended by the manufacturer for cast-in-place concrete floor slabs, curbs, equipment pads, tops and sides of containment walls, trenches, steps sumps, equipment pits and similar cast-in-place concrete items, described in Part 2, below.
      c. Provide a Novolac epoxy lining corrosion protection system at the chemical storage facilities in the chemical storage areas, as shown on the Drawings.
      d. Include manufacturer's recommended details for conditions encountered in the work and a Field Quality Control Report, including procedures, test methods, results of tests, remedial recommendations and actions.
      e. Provide complete technical services, as available from the manufacturer, and on-site technical representation by manufacturer's technical representative during the time of material delivery, storage, mock mock-up, substrate preparation and the advancement of installation to thirty percent of floor areas receiving concrete Novolac epoxy lining corrosion protection systems and during the start of field quality control testing.
   2. Extent of the Novolac epoxy lining corrosion protection system is shown on the Drawings and, in addition, includes the following:
      a. Bulk Containment Area:
         1) Floors, all equipment pads and supports, and walls up to the potential maximum liquid level.
      b. Feed Area:

1) Floors, equipment pads and supports and walls/curbing up to 8 inches.

c. Unloading Area:
1) Sump and driveway areas.

d. Bottoms and sides of all trench drains and horizontal pipe chases containing pipes transferring solutions from containment areas to point of use and all horizontal pipe chases within the containment areas.

3. Types of products required include the following:
a. The Novolac epoxy lining corrosion protection system shall be a two component, 100 percent solids, solvent-free, Novolac epoxy resin, silica filled, high-build protective and waterproofing coating. Concrete surface primer shall be a catalyzed epoxy resin containing conductive fillers, 100 percent solids content. Sealants are two component epoxy and two component polysulfide. Moisture barrier coating shall be two compo-nent polyurethane. Finish coats shall be a two component, 100 percent solids, Novolac epoxy resin.
b. The Novolac epoxy lining corrosion protection system shall be a two component, 100 percent solids, solvent-free, Novolac epoxy resin, silica filled, high-build protective and waterproofing coating. Concrete surface primer shall be catalyzed epoxy resin containing conductive fillers, 100 percent solids content. Rigid basecoat with reinforcement shall be Novolac epoxy resin with silica fillers and chopped strand fiberglass mat. Saturant for reinforcement shall be epoxy resin. Sealants are two component epoxy and two component polysulfide. Moisture barrier coating shall be two component polyurethane. Finish coats shall be two component, 100 percent solids, Novolac epoxy resin.
c. The Novolac epoxy lining corrosion protection system shall be a two component, 100 percent solids, solvent-free, Novolac epoxy resin, silica filled, high-build protective and waterproofing coating. Concrete surface primer shall be a catalyzed epoxy resin containing fillers, 100 percent solids content. Flexible basecoat with reinforcement shall be an epoxy resin with silica fillers and chopped strand fiberglass mat. Saturant for reinforcement shall be epoxy resin. Sealants are two component epoxy and two component polysulfide. Moisture barrier coating shall be two component polyurethane. Finish coats shall be a two component, 100 percent solids, Novolac epoxy resin.

B. Coordination:
1. Review installation procedures under other Sections and coordinate the installation of items that must be installed with, or before, the Novolac epoxy lining corrosion protection system.
2. Coordinate and schedule preparation of substrates, before equipment and similar items are installed to avoid later difficulty, or delay, in performing the Work of this Section, and to provide substrates within tolerances and surface profile specified.

3. Coordinate and schedule abrasive blasting of substrates to avoid later difficulty or delay in performing the Work.
4. Coordinate the setting of drains and other items in compliance with the recommended details of the Novolac epoxy lining corrosion protection system manufacturer for complete product responsibility.
5. Coordinate installation of reinforced epoxy resin topping corrosion protection system on existing surfaces with OWNER'S maintenance and operations staff.

1.2 QUALITY ASSURANCE

A. Installer Qualifications:
   1. Engage a single installer, certified or licensed by the Novolac epoxy lining corrosion protection system manufacturer, regularly performing trowel-applied lining installation, and with documented skill and successful experience in the installation of the types of materials required; and who agrees to employee only tradesmen who are trained, skilled and have successful experience in installing the types of materials specified.
   2. Submit name and qualifications to ENGINEER along with the following information on a minimum of three successful projects:
      a. Names and telephone numbers of owners, architects or Engineer's responsible for projects.
      b. Approximate contract cost of the Novolac epoxy lining corrosion protection system.
      c. Amount of area installed.
   3. Submit proof of acceptability of installer by manufacturer to ENGINEER.

B. Testing Agency Qualifications: To qualify for approval, an independent testing agency shall demonstrate to ENGINEER'S satisfaction, based on evaluation of criteria submitted by testing agency, that it has the experience and capability to satisfactorily conduct the testing indicated, in accordance with ASTM E 329 and as documented according to ASTM E 548, without delaying the Work.

C. Source Quality Control:
   1. Engage a single manufacturer who shall furnish the services of a technical representative to assist CONTRACTOR, ENGINEER and OWNER by providing technical opinions on the adequacy of materials and methods of installation and Site quality control testing. The Novolac epoxy lining corrosion protection system material manufacturer shall provide engineering field services to review the project and the material application prior to surface preparation: to approve the applicator, the materials used, and the procedure to be used; to provide the minimum pull-off adhesion strength, when testing for adhesion; to observe and approve surface preparation; and to observe application. The field representative of the Novolac epoxy lining corrosion protection system material manufacturer shall submit, through

CONTRACTOR, written approvals of the proposed protection system materials, application procedures, applicator, and surface preparation. The engineering field representative shall be an employee of the material manufacturer.

2. Furnish such services during the time of delivery, storage, mock-up installation, installation and on-site quality control testing of all Novolac epoxy lining corrosion protection system components.
3. Engage a manufacturer who will provide complete technical services including preparation and review of Shop Drawings, installation methods and proposed detailing.
4. Provide all components of the Novolac epoxy lining corrosion protection system produced by a single manufacturer, including recommended primers, base coat, chopped strand fiberglass mat, sealants and topcoat materials.
5. Certify product shelf life history for each system component. Do not use resins and catalysts manufactured more than six months prior to the time they will be incorporated into the Work.
6. Certify that all Novolac epoxy lining corrosion protection system materials have been stored in full compliance with all storage recommendations of the Novolac epoxy lining corrosion protection system manufacturer and that resins, catalysts and other sensitive auxiliary system components have been constantly stored between 50° and 75°F, and have not, nor will be, subjected to freezing temperatures.

D. Performance Criteria:
   1. Manufacturers of "or equal" products shall provide direct property comparison with the materials specified in addition to complying with all other requirements of the Specifications. "Or equal" products shall employ the same generic materials and system components as the Novolac epoxy lining corrosion protection system specified.
   2. CONTRACTOR'S Review: Submit to ENGINEER a written statement signed by CONTRACTOR, stating that the Contract Documents have been reviewed with the Novolac epoxy lining corrosion protection system material manufacturer who confirms that, if properly installed, the specified system is capable of providing performance criteria specified, is appropriate for installation shown on the Drawings and that the details proposed for use in the Work are not in conflict with the manufacturer's details.
   3. Statement of Application: Upon completion of the Novolac epoxy lining corrosion protection system Work, certify to ENGINEER and OWNER that the Work complies with the requirements of this Section, was installed in compliance with manufacturer's written recommendations, and that the installation methods were proper and adequate for the conditions of installation and use.

E. Referenced Standards: Comply with applicable provisions and recommendations of the following, except where otherwise shown or specified.

1. ASTM C 307, Test Method for Tensile Strength of Chemical-Resistant Mortar, Grouts and Monolithic Surfacings.
2. ASTM C 579, Test Method for Compressive Strength of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings and Polymer Concretes.
3. ASTM D 635, Test Method for Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position.
4. ASTM D 696, Test Method for Coefficient of Linear Thermal Expansion of Plastics.
5. ASTM D 2200, Pictorial Surface Preparation Standards for Painting Steel Surfaces.
6. ASTM D 4060, Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser.
7. ASTM D 4259, Practice for Abrading Concrete.
8. ASTM D 4263, Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method.
9. ASTM D 4285, Test Method for Indicating Oil or Water in Compressed Air.
10. ASTM D 4417, Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel.
11. ASTM D 4541, Test Method for Pull-Off Strength of Coatings Using Portable Adhesion-Testers.
12. ASTM D 7234, – Standard Test Method for Pull-off Adhesion Strength of Coatings on Concrete Using Portable Pull-off Adhesion Testers.
13. ASTM D 4787, Practice for Continuity Verification of Liquid or Sheet Linings Applied To Concrete Substrates.
14. ASTM E 329, Specification for Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction.
15. ASTM E 548, Guide for General Criteria Used for Evaluating Laboratory Competence.
16. ASTM F 1869, Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride.
17. National Association of Corrosion Engineers (NACE), Essentials of Surface Preparation.
18. Steel Structures Painting Council, SSPC - Volume 2, Systems and Specifications.
19. Steel Structures Painting Council, SSPC - PA2, Measurement of Dry Coating Thickness with Magnetic Gages.
20. Steel Structures Painting Council, SSPC - VIS 1, Visual Standard for Abrasive Blast Cleaned Steel.

F. Allowable Installation Tolerances:
   1. Do not install Work until substrate preparation and tolerances have been approved by ENGINEER, the Novolac epoxy lining corrosion protection system manufacturer’s technical representative and the Novolac epoxy lining corrosion protection system installer, and CONTRACTOR has verified to ENGINEER, in writing, that substrates are within tolerances and profiles

specified and acceptable to produce approved Work. Work advanced, for any reason, without such verification shall be stopped, and the Novolac epoxy lining corrosion protection system removed and replaced with new material if substrates are determined to be unacceptable for approved Work.

2. Substrate Tolerances:
   a. Out-of-Plane: 1/8-inch maximum in ten feet and 1/16-inch maximum in any 12-inches measured along the plane.
   b. Maximum Offset in Plane Alignment: 1/16-inch.
   c. Variation From Slope: 1/8-inch maximum in ten feet.
3. Novolac Epoxy Lining Corrosion Protection System Tolerances:
   a. Finish Novolac epoxy lining corrosion protection systems level to 1/8-inch in ten feet with smooth continuous uniformly sloped-to-drain planes.
   b. Provide smooth continuous color with no color streaks or inconsistencies with smoothly textured non-slip finish.

G. Pre-Installation Meeting:
1. Before erecting mock-ups, CONTRACTOR, installer, and technical representative of the Novolac epoxy lining corrosion protection system manufacturer shall meet on-site with ENGINEER to discuss approved products and workmanship to ensure proper application of the Novolac epoxy lining corrosion protection system components and substrate preparation requirements.
2. Review foreseeable methods and procedures related to the Novolac epoxy lining corrosion protection system Work, including, but not necessarily limited to, the following:
   a. Review Project requirements and the Contract Documents.
   b. Review required submittals, both completed and yet to be completed.
   c. Review status of substrate Work, including approval of surface preparations and similar considerations.
   d. Review requirements of on-site quality control testing and requirements for preparing quality control report as specified herein.
   e. Review availability of materials, tradesmen, equipment and facilities needed to make progress and avoid delays.
   f. Review required inspection, testing and certifying.
   g. Review environmental conditions, other Project conditions, and procedures for coping with unfavorable conditions.
   h. Review regulations concerning code compliance, environmental protection, health, safety, fire and similar considerations.
   i. Review procedures required for the protection of the Novolac epoxy lining corrosion protection system during the remainder of the construction period.
3. Record the discussions of the Pre-Installation Meeting and the decisions and agreements or disagreements reached, and furnish a copy for the record to

each party attending. Record any revisions or changes agreed upon, reasons therefore, and parties agreeing or disagreeing with them.

4. Reconvene the meeting at the earliest opportunity if additional information must be developed in order to conclude the subjects under consideration.

H. Mock-Ups:

1. Prior to the installation of the Novolac epoxy lining corrosion protection system and auxiliary system components, but after ENGINEER'S approval of samples and Shop Drawings, install eight-foot square stepped-back mock-ups of the systems showing each system component, in areas selected by ENGINEER, to show representative installation of the Work. Include methods of installation typical to the Work, including penetrations and cove details, using all system components required for the Work.
2. Obtain ENGINEER'S acceptance of visual qualities of the mock-ups before start of a Novolac epoxy lining corrosion protection system Work. Retain and protect mock-ups during construction as one standard for judging completed a Novolac epoxy lining corrosion protection system Work. Do not alter mock-ups after approval by ENGINEER.
    a. Finished Work, in compliance with visual qualities of mock-ups, that fails other on-site quality control testing procedures shall be replaced by CONTRACTOR with new materials.
3. Novolac epoxy lining corrosion protection system Work that does not meet the standard approved on the sample areas shall be removed and replaced with new material.
4. Build as many mock-ups as required to achieve ENGINEER'S acceptance of the Novolac epoxy lining corrosion protection system.
5. Novolac epoxy lining corrosion protection system Work that proceeds without approved mock-ups shall be stopped, and mock-ups prepared for approval.

1.3 SUBMITTALS

A. Samples: Submit for approval the following:

1. Stepped-back Novolac epoxy lining corrosion protection system applied to a 12-inch by 12-inch by 2-inch concrete sample panel showing specified surface preparation of concrete, each showing original unprepared surface in addition to each component of the Novolac epoxy lining corrosion protection system. Prepare sample panels such that all system components are adequately exposed to view. Apply Novolac epoxy lining corrosion protection system to only one-half of the sample board, leaving the other half visible and with required substrate preparation.
2. Full selection of manufacturer's standard and custom colors for selection by ENGINEER. ENGINEER will preliminarily select a maximum of four colors for consideration for use in the Work. Prepare 12-inch by 12-inch samples of each color. From these the ENGINEER will select a maximum of

four colors to be used in the Work. ENGINEER will provide CONTRACTOR with locations of each color after this final selection. In addition to color, provide range of textures from smooth to heavily non-slip for selection for use on job mock-up panel.

3. Sample submittals will be reviewed for number of system components only. Compliance with all other requirements is the responsibility of CONTRACTOR.

B. Shop Drawings: Submit for approval the following:
   1. Copies of specifications, technical information, installation instructions and general recommendations from the Novolac epoxy lining corrosion protection system manufacturer for lining required. Include requirements for environmental conditions and other conditions required for an acceptable installation, providing features and performance as stated in manufacturer's literature.
   2. Drawings showing extent of each component of each system used in the Work including all items receiving Novolac epoxy lining corrosion protection system such as equipment pads, curbs, sumps, pipe trenches and similar items and surfaces and all details required for the Work referencing required system components provided as samples to ENGINEER. Provide working drawings coordinated with cast-in-place concrete and showing all construction, and other conditions encountered in the Work and manufacturer's approved and recommended details appropriate to construction, expansion and seismic joints as required for full Novolac epoxy lining corrosion protection system performance whether or not specific indication is made on the Drawings to the details of the Novolac epoxy lining corrosion protection system.
   3. Show interface details with other items such as thresholds, curbs, coves, equipment pads, expansion and seismic joint cover assemblies, floor hatches, ramps, steps and stair nosings.
   4. Copies of Material Safety Data Sheets (MSDS) for all products used in the Work and copies of transmittals indicating receipt of MSDS by Novolac epoxy lining corrosion protection systems installer.
   5. Qualifications Data: Submit qualifications data for the following:
      a. Installer.
      b. Testing laboratory.
   6. Maintenance Manual: Five copies of manufacturer's written instructions for recommended maintenance practices. Include the following information:
      a. Product name and number.
      b. Name, address and telephone number of manufacturer and local distributor.
      c. Detailed procedures for routine maintenance and cleaning.
      d. Detailed procedures for repairs.

C. Test Reports: Submit the following:
   1. Copies of test reports from an independent testing laboratory for all physical properties of the Novolac epoxy lining corrosion protection system.
   2. Copies of testing agencies background and experience in performing similar tests to those specified.
   3. Final On-Site Quality Control Report: Provide ENGINEER with testing results in each area of the Work, manufacturer's recommended remedial measures, weather, humidity and dew point conditions during the time of installation and curing of the Work, and other requirements as specified for final approval.

D. Component Application and Thickness Report:
   1. Copies of reports listing each component application, dry film thickness, surface temperature, component temperature, and ambient air temperature.

E. Certificates: Submit the following:
   1. Certificates stating that materials meet or exceed Specification requirements and stating that materials have been provided as specified to meet performance criteria, and installation requirements specified.
   2. Shelf life history for all products, verifying compliance with requirements specified.
   3. Evidence of acceptance of the substrate and each system component installation by the Novolac epoxy lining corrosion protection system materials manufacturer's technical representative. Include such documentation as part of the on-site quality control report submitted to ENGINEER for final approval.
   4. CONTRACTOR'S Review: Submit specified statement to ENGINEER. Show by copy of transmittal form that a copy of the statement has been transmitted to the manufacturer.
   5. Submit statement of application, as specified.

F. Warranties: Submit CONTRACTOR'S and manufacturers written warranties.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Delivery of Materials:
   1. Deliver materials in the Novolac epoxy lining corrosion protection system manufacturer's original unopened and undamaged containers, legibly labeled with information accurately representing container contents, as approved by ENGINEER.
   2. Include the following information on the label:
      a. Name of material, manufacturer and supplier.
      b. Brand name, contents, and order number.
      c. Installation, handling and protection requirements.
      d. Accurate representation of DOT classifications.

3. Deliver materials in sufficient quantities to allow uninterrupted continuity of the Work.
4. Packages showing indications of damage that may affect condition of contents are not acceptable.
5. All DOT classified system components shall be accompanied by appropriate DOT documentation.

B. Storage of Materials:
1. Store only approved materials on-site.
2. Store materials in original, undamaged containers with manufacturer's labels and seals intact.
3. Store all materials in a dry, enclosed area, off the ground and away from all possible contact with water and in a location where temperature can be constantly maintained between 50°F and 75°F and out of direct sunlight, away from open flame, sparks or other hazards in full compliance with manufacturer's recommended storage requirements.
4. Prevent damage to materials during storage primarily by minimizing the amount of time they are stored on-site before being incorporated into construction systems.
5. Do not store either white, yellow or red labeled products together.

C. Handling of Materials:
1. Do not handle, open or mix component materials, unless Novolac epoxy lining corrosion protection system can be properly handled as recommended by the manufacturer.
2. Do not open containers, or expose materials to detrimental conditions. Remove materials so exposed from the site.
3. Handle materials in a manner that prevents contamination and inclusion of foreign materials.
4. Do not open packages or containers until all necessary preparatory Work is complete, approved and installation will begin immediately.
5. Handle all materials in strict compliance with manufacturer's recommended safety precautions.
6. Handle volatile system components in a manner that considers their flash points.

1.5 PROJECT CONDITIONS

A. Environmental Conditions:
1. Proceed with Novolac epoxy lining corrosion protection system Work only when temperature and moisture conditions of substrates, air temperature, relative humidity, dewpoint and other conditions comply with the Novolac epoxy lining corrosion protection system manufacturer's written recommendations and when no damaging environmental conditions are forecasted for the time when the materials will be vulnerable to such

environmental damage. Record all such conditions and include in final site quality control report.

2. Maintain substrate temperature before, during and after installation between 50°F and 110°F with temperature stable or falling, in accordance with Novolac epoxy lining corrosion protection system manufacturer's instructions.
3. Do not begin Work when relative humidity is expected to rise above 90 percent during the time of installation and catalyzation, nor, when substrate temperatures are not at least five degrees above the dewpoint temperature.
4. Do not begin Novolac epoxy lining corrosion protection system Work until manufacturer's recommended environmental conditions can be maintained and only when manufacturer and installer are willing to guarantee the Work as required and without additional reservations and restrictions.
5. Supplemental Heat:
    a. Provide supplemental heat and protection as required to maintain Novolac epoxy lining corrosion protection system at minimum of 50°F during and after installation.
    b. Supplemental heat and power sources, as may be required should ambient temperature fall below 50°F, are not available at the site. The provision of all supplemental heat, including fuel, equipment, operating, monitoring and maintenance personnel, and power sources, is the responsibility of CONTRACTOR.
    c. Distribute heat uniformly and provide deflection or protective screens as required to prevent concentration of heat on the Novolac epoxy lining corrosion protection system near heat source.
    d. Source of supplemental heat shall not emit contaminants that will adversely affect the cure or performance of the Novolac epoxy lining corrosion protection system. Novolac epoxy lining corrosion protection systems so affected shall be removed and replaced with new.

B. Protection and Precautions:
1. Protect materials against damage by construction activities.
2. Protect all Novolac epoxy lining corrosion protection system materials and system components from all contact with non-associated construction traffic.
3. Do not install the Novolac epoxy lining corrosion protection system when adequate protection of the Work is not, or cannot, be made available.
4. Comply with manufacturers' written safety precautions for storage, handling, mixing and installation of each component, and with the requirements of OSHA and local governing authorities having jurisdiction at the site.
5. Environmentally isolate and enclose the Work area so that adjacent Work, and personnel adjacent to the Work area, will be unaffected by the Work of this Section.
6. Provide adequate ventilation for space and appropriate protective life support respirators for installers, during installation and curing periods, with exhaust air adequately diluted and discharged to a safe location. Avoid build-up of

hazardous vapors or the creation of hazardous conditions or conditions that may retard the cure of the system.

7. Provide suitable glasses, gloves, respirators and suitable personnel protective clothing for use during installation of the Novolac epoxy lining corrosion protection system.
8. Provide protection of substrate surfaces, including Work protection shelters, to prevent substrate temperatures from exceeding manufacturer's recommended installation limits.

C. Sequencing and Scheduling:
   1. Proceed with the Novolac epoxy lining corrosion protection system only after projections and penetrations through the substrates have been installed, and when the substrate construction and framing of openings is complete.
   2. Coordinate and schedule abrasive blasting, grinding and filling of substrates with underlayments, in order to bring substrates within tolerances specified.
   3. Provide Novolac epoxy lining corrosion protection system on top of equipment pads, within horizontal pipe chases and similar locations where installation of equipment, piping and similar items would cause the Novolac epoxy lining corrosion protection system installation difficulties, before such equipment, piping and similar items have been installed. In order to advance the Work, be prepared to schedule multiple visits of a Novolac epoxy lining corrosion protection system installer to the site for the purpose of installing the Novolac epoxy lining corrosion protection system in areas that will become inaccessible with the installation of equipment or piping, as may be required for proper sequencing of the Work.
   4. Sequence the Work so that other installers do not interfere with, or need to cross, the Novolac epoxy lining corrosion protection system installation areas until such time as the Novolac epoxy lining corrosion protection system can be adequately protected from potential damage.

D. Substitutions:
   1. Do not change products, system components, colors or manufacturers after Shop Drawing and Samples approvals by ENGINEER.
   2. Clearly identify, in a manner which is highlighted to ENGINEER, all proposed substitutions, modifications, variations, unspecified features and "or equal" products. Provide complete comparative data with specified products at time of Shop Drawing submission.

1.6 WARRANTY

A. General Warranty: The special warranties specified in this Article shall not deprive OWNER of other rights or remedies OWNER may otherwise have under the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by CONTRACTOR under the Contract Documents.

B. Bonded Warranty: The corrosion protection system applicator shall supply a two year bond, payable to the City of Phoenix (COP), for the corrosion protection system that is approved by COP. The two year bond shall cover both the material costs and the labor costs associated with installing the approved corrosion protection system. The bond shall also be unconditional in nature covering any type of failure in the corrosion protection system and agreeing to repair or replace it at no additional cost to COP at any point during this two year period. The corrosion protection system applicator shall also supply a warranty from the corrosion protection system manufacturer addressed to the A-minus or better bonding company and COP. This warranty shall state, at a minimum, that if the corrosion protection system is applied in accordance with the manufacturer's instructions, that the corrosion protection system will not fail for a period of two years. The definition of a corrosion protection system failure is that blistering, cracking, embrittlement, or softening of the corrosion protection system is starting to occur.

PART 2 - PRODUCTS

2.1 SYSTEM PERFORMANCE

A. Performance Criteria:
   1. General:
      a. Standards: Comply with applicable standards, recommendations and specified publications of ASTM, except to the extent more stringent requirements are specified or required by governing authorities having jurisdiction.
   2. The completed Novolac epoxy lining corrosion protection system shall demonstrate the following physical properties:
      a. Compressive Strength, ASTM C 579: 9,000 to 9,5000 pounds per square inch, minimum.
      b. Tensile Strength, ASTM C 307: 3,000 to 3,500 pounds per square inch, minimum.
      c. Abrasive Factor, CS-17 wheel, 1000 cycles, 1000-gram load, ASTM D 4060: 72 mg.
      d. Water Vapor Transmission: 0.0018 perm. in.
      e. Flame Spread, ASTM D 635: < 5mm.
   3. The completed Novolac epoxy lining corrosion protection system shall demonstrate the following physical properties:
      a. Compressive Strength, ASTM C 579: 6,000 to 7,000 pounds per square inch, minimum.
      b. Tensile Strength, ASTM C 307: 4,000 to 5,000 pounds per square inch, minimum.
      c. Abrasive Factor, CS-17 wheel, 1000 cycles, 1000-gram load, ASTM D 4060: 72 mg.
      d. Flame Spread, ASTM D 635: 33mm.

4. The completed Novolac epoxy lining corrosion protection system shall demonstrate the following physical properties:
   a. Compressive Strength, ASTM C 579: 6,000 pounds per square inch, minimum.
   b. Tensile Strength, ASTM C 307: 4,500 to 5,000 pounds per square inch, minimum.
   c. Abrasive Factor, CS-17 wheel, 1000 cycles, 1000-gram load, ASTM D 4060: 72 mg.

B. The finished Novolac epoxy lining corrosion protection system shall be capable of providing splash and spill protection for 72 hours, at temperatures from 50° to 150°F, from the chemical exposures, listed below, with no adverse effects. Products capable of only intermittent spill exposure resistance are not acceptable. The Novolac epoxy lining corrosion protection system will be exposed to sunlight and atmospheric conditions.
   1. 98 Percent Sulfuric Acid, 150°F.

2.2 MATERIALS

A. Resin: Catalyzed, Novolac epoxy: With silica fillers.

B. Concrete Surfacer: Provide a two-component, epoxy-based material with inert mineral fillers recommended by the Novolac epoxy lining corrosion protection system manufacturer for filling concrete “bug” holes and voids in horizontal and vertical concrete surfaces, complying with the following:
   1. Adhesion to Concrete, ASTM D 4541: Cohesive failure of concrete.
   2. Compression Strength, ASTM C 579: 2000 pounds per square inch, minimum.

C. Moisture Barrier Coating: Two component water dispensed polyurethane, complying with the following:
   1. Compressive strength, ASTM C 579: 7,300 pounds per square inch, minimum.
   2. Tensile strength, ASTM D 4541: Cohesive failure of concrete.

D. Primer: Two component, 100 percent solids, moisture-tolerant, conductive catalyzed epoxy, complying with the following:
   1. Tensile Strength, ASTM C 307: 2,000 to 2,500 pounds per square inch.
   2. Tensile Elongation, ASTM C 307: 20 to 25 percent.
   3. Adhesion to Concrete, ASTM D 4541: Cohesive failure of concrete.

E. Reinforcement: One ounce chopped strand fiberglass mat.

F. Topcoat: Catalyzed, Novolac epoxy with silica fillers.

G. Auxiliary System Components and Accessories: Provide all auxiliary components such as accelerators, solvents, saturants, fillers, sand, smoothing liquids, hardeners and cleaners as recommended by the manufacturer for maximum chemical-resistance, maximum adhesion to substrate and full system component compatibility.

H. Sealants:
1. Exposed floor joints: Two component, 100 percent solids, polysulfide polymer based joint sealant.
2. Non-moving joints, covered with topping: 100 percent solids, pourable, two component, flexible epoxy caulk.
3. All wall joints: Two component, 100 percent solids, polysulfide polymer based joint sealant.

I. Novolac Epoxy Lining Corrosion Protection System Manufacturer:
1. The corrosion protection system specified is manufactured by Dudick, Inc. Equivalent protection systems of other manufacturer's regularly producing high quality concrete corrosion protection systems and materials including providing the required material manufacturer's engineering field services may be furnished subject to review and acceptance by ENGINEER.

J. Product and Manufacturer: Provide one of the following:
1. PROTECTO-COAT 100XT Lining System, with Scratch-Coat 300 Surfacer, Primer 67C, Shock-Crete F moisture barrier coating and Caulk 100XT, 139 and 149, by Dudick, Incorporated.
2. PROTECTO-GLASS 160XT Lining System, with Scratch-Coat 300 Surfacer, Primer 67C, Shock-Crete F moisture barrier coating and Caulk 100XT, 139 and 149, by Dudick, Incorporated.
3. PROTECTO-FLEX 100XT Lining System with Scratch-Coat 300 Surfacer, Primer 67C, Shock-Crete F moisture barrier coating and Caulk 100XT, 139 and 149, by Dudick, Incorporated.

PART 3 - EXECUTION

3.1 INSPECTION

A. Examine the areas and conditions under which the Novolac epoxy lining corrosion protection system Work is to be performed and notify ENGINEER, in writing, of conditions detrimental to the proper and timely completion of the Work. Do not proceed with the Work until satisfactory conditions have been corrected in a manner acceptable to ENGINEER.

B. Concrete shall have a wood float finish. Concrete shall have cured for minimum of 28 days prior to initiation of this Work.

3.2 PREPARATION FOR CAST-IN-PLACE CONCRETE SUBSTRATES

A. Concrete shall be free of curing compounds and form release agents.

B. Test cast-in-place concrete for moisture, in compliance with ASTM D 4263, in order to determine that the maximum safe moisture-emission level, recommended by the Novolac epoxy lining corrosion protection system manufacturer's written installation limitations, will not be exceeded, before installation of the Novolac epoxy lining corrosion protection system.
   1. Perform minimum of one test for every 1000 square feet of substrate area to receive the Novolac epoxy lining corrosion protection system. Perform tests on areas scheduled to be coated the following day.
   2. If moisture tests indicate unacceptable levels of moisture remaining in the substrate, do not install the Novolac epoxy lining corrosion protection system. Report existing conditions, along with manufacturer's recommendations, to ENGINEER. Allow additional time for cast-in-place concrete to dry and retest.
   3. At CONTRACTOR'S option and expense, may enclose, dehumidify or provide additional heat, in order to speed the drying process. If, after remediation measures are implemented, retesting the cast-in-place concrete continues to indicate unacceptable levels of moisture, perform calcium chloride tests in accordance with ASTM F 1869. If readings are below 5 pounds per 1,000 square feet for 24 hours install the primer. If readings are between 5 and 8 pounds per 1,000 square feet for 24 hours install the moisture barrier coating, if readings are over 8 pounds per 1,000 square feet for 24 hours submit the Novolac epoxy lining corrosion protection system manufacturer's recommended remedial action for ENGINEER'S approval.

C. Prepare and clean all surfaces of cast-in-place concrete to receive the Novolac epoxy lining corrosion protection system in compliance with ASTM D 4259 to obtain a uniform and continuous anchor profile and to provide a surface texture similar to 40 to 60-grit sandpaper with aggregate showing. Use mechanical abrading procedures and abrasive blasting procedures as specified in ASTM D 4259. Use 40 to 80-mesh abrasive and clean, dry, compressed air. Compressed air cleanliness shall be in compliance with ASTM D 4285. Pressure at blasting nozzle shall not exceed 80 psi. Do not concentrate blast on surface, but move at a fairly rapid rate to provide a surface free of laitenance and contaminants. Provide post-surface preparation cleaning in accordance with ASTM D 4258 to remove loose material. Surface preparation shall open all surface air holes by removing all laitance shoulders surrounding the air holes. Vacuum all surfaces to remove all dust and sand, and wash with potable water.
   1. Provide additional surface preparation if 40 to 60-grit texture with aggregate showing is not achieved after the first mechanical preparation procedure.

2. All surface laitance and other contaminants shall be completely removed and surface profile shall be as specified, before commencement of surfacer installation.

D. In addition to abrasive blasting, level and grind cast-in-place concrete substrates to manufacturer's recommended tolerances and to produce a smooth, uniform installation.
   1. Remove all cast-in-place concrete fins, projections and other surface irregularities that would protrude above the surfacer and finished base coat, by chipping and scarification by mechanical abrasion.

E. Adhesion Testing: Before application of the Novolac epoxy lining corrosion protection system, an adhesion test shall be conducted on a properly prepared concrete surface that is acceptable to the material manufacturer and ENGINEER. The test area shall be at least two square feet or larger to allow a minimum of three tests to be conducted. The test area shall be coated with the specified system and cured as recommended by the material manufacturer. Pull-off strength adhesion tests of protection system shall be conducted by the material manufacturer in accordance with ASTM D 4541, using an Elcometer tensile adhesion tester. At least three adhesion tests shall be conducted and the results averaged. Adhesion strength shall equal or exceed the minimum adhesion strength recommended by the material manufacturer and shall exceed the tensile strength of the concrete. If the protection system fails the adhesion test, the cause of the failure shall be determined and corrected before re-conducting the test.

F. Start of the Novolac epoxy lining corrosion protection system installation operations shall indicate acceptance of substrate conditions and full responsibility for the completed Work.

3.3 SYSTEMS INSTALLATION

A. The Novolac epoxy lining corrosion protection system shall be applied in three or more coats. The Novolac epoxy lining corrosion protection system shall consist of one prime coat and two or more finish coats. The prime coat wet film thickness shall be at least six mils. Surfacer thickness will vary depending on concrete texture. Moisture barrier coating shall be 125 mils, minimum. Each finish coat shall be 15 to 20 mils dry film thickness. The Novolac epoxy lining corrosion protection system shall have a total dry film thickness of at least 40 mils.

B. The Novolac epoxy lining corrosion protection system shall be applied in four or more coats. The Novolac epoxy lining corrosion protection system shall consist of a prime coat, a rigid reinforced basecoat, reinforcement and saturant, and two or more finish coats. The prime coat shall be at least six mils wet film thickness. Surfacer thickness will vary depending on concrete texture. Moisture barrier

coating shall be 125 mils, minimum. The basecoat shall be trowel applied, to a thickness of 63 mils (1/16-inch). The reinforcement shall be pressed firmly into the basecoat, and then saturated with the basecoat resin mixture. Each finish coat shall be 15 to 20 mils dry film thickness. The Novolac epoxy lining corrosion protection system shall have a total dry film thickness of at least 100 mils.

C. The Novolac epoxy lining corrosion protection system shall be applied in four or more coats. The Novolac epoxy lining corrosion protection system shall consist of one prime coat, one basecoat, reinforcement and saturant, and two or more finish coats. The prime coat wet film thickness shall be at least six mils. Surfacer thickness will vary depending on concrete texture. Moisture barrier coating shall be 125 mils, minimum. The basecoat shall be trowel applied, to a thickness of 63 mils (1/16-inch). The reinforcement shall be pressed firmly into the basecoat, and then saturated with the basecoat resin mixture. Each finish coat shall be 15 to 20 mils dry film thickness. The Novolac epoxy lining corrosion protection system shall have a total dry film thickness of at least 100 mils.

3.4 INSTALLATION ON CAST-IN-PLACE CONCRETE SUBSTRATES

A. Primer:
   1. Prime all cast-in-place concrete to receive the Novolac epoxy lining corrosion protection system immediately after surface preparation in order to prevent degradation of prepared surfaces.
      a. All surfaces shall be free of all laitenance and other contaminants at time of commencement of primer installation.
   2. Mix primer components as recommended by the Novolac epoxy lining corrosion protection system manufacturer. Add accelerator only after consultation with manufacturer's technical representative and with the approval of ENGINEER and based on agreement as to the best approach for handling environmental conditions existing at the site during installation.
   3. Apply conductive primer using roller, prior to application of surfacer and base coat and in accordance with manufacturer's approved Shop Drawings.

B. Follow manufacturer's written instructions for mixing and catalyzing process. Install all system components within their maximum recoat times based on manufacturer's written information, the environmental conditions existing at the site and the exposure of system components to sunlight during installation.
   1. If maximum recoat time is exceeded, sand or abrasive blast as recommended by manufacturer's technical representative in consultation with ENGINEER, before installation of topcoat.

C. Install surfacer when primer is tacky. Trowel-apply specified surfacer and patch all cast-in-place concrete surfaces to completely fill surface air holes and honeycombing. Level all protrusions and grind filler and surfacing compounds smooth and level with adjacent surfaces.

D. Trowel-apply specified moisture barrier coating over surfacer to form level surface.

E. A Novolac epoxy lining corrosion protection system shall be installed on all exposed cast-in-place concrete surfaces shown on the Drawings and specified.

F. Mix materials in the sequence required by the manufacturer.

G. After primer has dried examine surfaces for oily, amine-blush film. Remove film by washing with warm water-detergent solution.

H. Mix materials and install base coat in accordance with manufacturer's instructions.

I. Press the chopped strand fiberglass mat reinforcement into the wet base coat. Lap all glass reinforcement edges 1-inch minimum. Remove all air pockets and wrinkles. Roll glass reinforcement until it has lost its white color and turns translucent.

J. Saturate the glass reinforcement with catalyzed resin; do not puddle saturant or allow to drip.

K. Lightly broadcast clean, dry sand into the wet saturant.

L. Allow base coat to cure before proceeding. Examine base coat for amine blush and, if present, remove it by washing with a warm water detergent solution. Grind and repair sharp glass protrusions and fill voids.

M. Brush, roll or spray apply topcoat as recommended by the Novolac epoxy lining corrosion protection system manufacturer.

N. Repeat trowel-applied topcoat material as recommended by manufacturer for complete coverage.

O. Apply materials to tolerances specified and in the recommended quantities necessary to produce a finished system thickness as specified.

P. Install Novolac epoxy lining corrosion protection system expansion and construction joints at all concrete expansion and control joints as recommended by the manufacturer.

3.5 SITE QUALITY CONTROL TESTING

A. The right is reserved by ENGINEER to invoke the following material testing procedure at any time, and any number of times, during the period of the Novolac epoxy lining corrosion protection system installation:
   1. Engage the service of an independent testing laboratory to sample any of the system components being used. Samples of each material delivered to the site will be taken, identified and sealed, and certified as to being the material actually applied to the surfaces in each area.
   2. A testing laboratory, selected by OWNER, as indicated in Division 1, General Requirements, will perform appropriate tests for any or all of the following characteristics:
      a. Abrasion resistance.
      b. Flexibility.
      c. Wash ability.
      d. Absorption.
      e. Chemical resistance.
      f. Dry opacity.
      g. Generic materials analysis including compressive strength, tensile strength and water vapor transmission.
   3. If the test results show that the material being used does not comply with the specified requirements, ENGINEER may direct CONTRACTOR to stop the installation and remove non-complying Novolac epoxy lining corrosion protection system; pay for testing; and prepare and repaint surfaces coated with the rejected system with material complying with the Specifications.

B. CONTRACTOR will notify ENGINEER after completion of installation of each component of the Novolac epoxy lining corrosion protection system. After inspection and checking of film thickness, and for other imperfections, and after approval by ENGINEER, proceed with the succeeding coat. Provide dry-film thickness gages for checking the film thickness and visual standards to check surface preparation. Calibrate dry film thickness gage at the site using Bureau of Standards standard shim blocks. Provide holiday detector for holiday testing. The holiday detector will remain the property of CONTRACTOR.
   1. Product and Manufacturer: Provide the following:
      a. Film Thickness Tester: Model FM-III as manufactured by Mikrotest, (Furnish Two).
      b. Holiday Detector: Model M-1 as manufactured by Tinker & Rasor.
      c. Visual Standards - ASTM D 2200 and SSPC (VIS 1).
   2. ENGINEER shall witness all holiday testing and shall be notified of all scheduled testing 24 hours in advance.
   3. Additional coats shall be applied, if required, to produce the specified film thickness and to correct holidays and to completely fill all surface air holes.

C. Measure thickness of dry film nonmagnetic coatings following recommendations of SSPC-PA 2. These procedures are intended to supplement manufacturers'

approved instructions for the manual operation of measurement gages and are not intended to replace them.

D. Chemical Resistant Testing: After approval of job mock-up and substrate preparations, install Novolac epoxy lining corrosion protection system to a minimum of eight square feet, for each system specified, within a chemical containment area. Installation of test area shall be supervised and approved by manufacturer's Technical Representative as an acceptable installation. Test the Novolac epoxy lining corrosion protection systems for a minimum of 48 hours at normal operating temperatures. Place specified chemicals at normal operating temperature to a minimum depth of 1/2-inch over the entire floor surface of the area. Maintain operating temperature of space and specified chemicals. After 48 hours remove the chemical and inspect the surfaces of the Novolac epoxy lining corrosion protection systems. The Novolac epoxy lining corrosion protection systems shall show no sign of delamination, cracking, crazing, color change, softening or any other physical or chemical changes whatsoever and shall be unaffected from the immersion condition. If the Novolac epoxy lining corrosion protection systems show deterioration, the test may be repeated at CONTRACTOR'S expense. If the Novolac epoxy lining corrosion protection systems fail to perform according to Specification at the completion of this second test, the Novolac epoxy lining corrosion protection systems shall be rejected by ENGINEER and an "approved equal" product shall be submitted for approval by CONTRACTOR. Test "approved equal" product as specified herein.

E. After each component of the reinforced epoxy resin topping corrosion protection system has completely cured the material manufacturer shall record the dry film thickness and submit a report to the ENGINEER listing all components and thicknesses.

F. Mark and repair all pinholes and repair using topcoat material. After the Novolac epoxy lining corrosion protection system is installed, the material manufacturer shall spark-test all concrete surfaces covered with the Novolac epoxy lining corrosion protection system with a 20,000-volt AC spark tester in accordance with ASTM D 4787 and set at the recommended voltage, or as a minimum at 100 volts per mil of liner thickness. The material manufacturer shall verify the testing equipment is working properly before beginning the spark testing of the lining. The electrode movement shall be continuous and shall proceed in a systematic manner that will cover 100 percent of the lining surface. A carbon fiber brush shall be used on the sensor electrode. Retest repair after curing.

3.6 ADJUSTMENT AND CLEANING

A. All finished Novolac epoxy lining corrosion protection systems shall be protected from damage until Final Completion of the Work. The Novolac epoxy lining

corrosion protection system damaged in any manner shall be repaired or replaced as required to restore specified system performance.

B. Only the original installer of the Novolac epoxy lining corrosion protection system shall replace deteriorated or defective Work.

C. Protection: Care shall be taken to prevent protection system materials from being dropped or spilled on adjacent surfaces, buildings, structures, or facilities. All surfaces so damaged shall be cleaned, repaired, replaced, or coated as acceptable to the ENGINEER.

+ + END OF SECTION + +

SECTION 11001

ELECTRIC MOTORS LARGER THAN 250 HORSEPOWER

PART 1 – GENERAL

1.1 DESCRIPTION

A. Scope:
   1. This Section includes alternating current induction motors that are larger than 250 horsepower. They require the additional features or criteria specified. Unless specified otherwise, electric motors shall be provided by the manufacturer of the driven equipment under an assumption of unit responsibility. The Contractor shall assign unit responsibility to the manufacturer for the equipment specified and a certificate of unit responsibility shall be provided. This Section refers to motors by enclosure type as defined in NEMA MG 1, except as noted.

B. Horsepower Rating:
   1. Motor horsepower ratings noted in individual equipment Specifications are estimates only and it is the responsibility of CONTRACTOR to furnish motors, electric circuits, and other equipment of ample horsepower capacity to operate the equipment furnished without exceeding the manufacturer's nameplate full-load current at rated manufacturer's nameplate voltage. Full-load current information shall be furnished with the individual submittals.

1.2 QUALITY ASSURANCE

A. General: Motors shall be built in accordance with UL 674, UL 1004, NEMA Standard MG 1, and to the requirements specified.

B. Reference Standards: Comply with applicable provisions and recommendations of the following, except as otherwise shown or specified. In case of conflict between the requirements of this Section and those of the listed documents, the requirements of this Section shall prevail.
   1. AFBMA 9: Load Rating and Fatigue Life for Ball Bearings.
   2. AFBMA 11: Load Ratings and Fatigue Life for Roller Bearings.
   3. IEEE 112: Standard Test Procedures for Polyphase Induction Motors and Generators.
   4. IEEE 841: Standard for Petroleum and Chemical Industry - Totally Enclosed Fan Cooled (TEFC) Squirrel Cage Induction Motors - Up to and Including 500 HP.
   5. NEMA ICS 2: Industrial Control Devices, Controllers and Assemblies.
   6. NEMA ICS 6: Enclosures for Industrial Controls and Systems.

7. NEMA MG 1: Motors and Generators.
8. NEMA MG1-31: Application Considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General Purpose Motors Used with Adjustable-Voltage or Adjustable- Frequency Controls or Both.
9. UL.674: Electric Motors and Generators for Use in Class I Division I Hazardous Locations
10. UL 1004: Electric Motors.

C. Factory Tests: The motors larger than 250 horsepower shall be subject to the manufacture's complete factory dynamometer tests per IEEE Standard 112 Appendix-B
   1. Standard routine factory tests.
   2. Full Load Heat Run.
   3. Temperature Rise at full load.
   4. Breakdown Torque.
   5. Rated Full Load Slip.
   6. Speed-Torque Curves.

D. Warranty:
   1. Motors greater than 250 horsepower shall be warranted against defects in materials and workmanship for a period of 5 years under the specified uses and with normal operation and service. This warranty shall be delivered, in writing, to the Owner and shall include, as a minimum, 100 percent full payment coverage for parts and labor during the first 60 months of operation.

E. Unit Responsibility: Assign Unit Responsibility as specified in Section 01600, General Equipment Provision, to the manufacturer for the equipment specified in this Section. A Certificate of Unit Responsibility shall be provided.

1.3 SUBMITTALS

A. Submittals shall include the following:
   1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates 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.
      a. 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.
      b. The Construction Manager 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.

c. 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.

2. Manufacture completed IEEE Standard 841 Date Sheet for AC Squirrel Cage Induction Motors with required factory data of motors supplied.
3. Speed-Torque curve per 1. 2 C Factory Tests.
4. Factory Test Data: Including Guaranteed Minimum Efficiency for 115% load, 100% load, 75% load, 50% load, and no load.
5. Guaranteed vibration level when measured per MG 1, Figure 7-6:
   a. Displacement: 0.0025 inch peak-to-peak
   b. Velocity: 0.10 inches per second peak
   c. Acceleration: 1g (gravity) peak.
6. Motor heating curve for motors per 1.2 C Factory Tests.
7. Motor outline, dimensions, and weight.
8. Manufacturer's descriptive information relative to motor features.
9. Response curve where a winding over-temperature device is required.
10. For all inverter duty motors: Manufacturer's certification that the motor is compatible with the adjustable frequency drive to be used.
11. Disassembly and repair documentation.

1.4 POWER SUPPLY VARIATIONS

A. Motors shall operate successfully under running conditions at rated load with +/- 10-percent of rated voltage with rated frequency or +/- 5-percent of rated frequency with rated voltage.

B. Provide power factor correction capacitors, as specified in Section 16281 – Power Factor Correction Capacitors, for the following motors.
   1. (--1--)

1.5 AMBIENT CONDITIONS

A. Unless specified otherwise, motors shall be suitable for continuous operation at an elevation of approximately 1,000 feet above mean sea level. Motors to be installed outdoors, exposed to the weather, shall be suitable for continuous operation in a 50° C ambient temperature; motors to be installed indoors shall be suitable for continuous operation in 50° C ambient temperature, unless otherwise noted.

1.6 NEMA WINDING TEMPERATURES

A. NEMA MG 1 Table 12-7 motors insulation system maximum winding temperatures in degrees-Centigrade (C), with the degrees-Fahrenheit (F) insulation system class specified herein.
   1. Forty degree-C ambient (104 degree-F) is the basis for temperature rise.
   2. For 50 degree C ambient (122F) and above, refer to the driven equipment specifications for additional requirements.

Insulation System Class	Degrees C / F	Temperature Rise by Resistance
A	140 / 284	NA
B	165 / 329	B-rise: 40 + 80 = 120 Degrees C / 248 F
F	190 / 374	F-rise: 40 + 105 = 145 Degrees C / 293 F
H	215 / 419	H-rise: 40 + 125 = 165 Degrees C / 329 F

1.7 NEMA MOTOR TEMPERATURE PROTECTION TYPES

A. The NEMA design shall limit the temperatures of the windings without using a thermal device:
   1. Type-1: Winding Running and Locked Rotor Over-temperature Protection.
   2. Type-2: Winding Running Over-temperature Protection.

PART 2 - PRODUCTS

2.1 MANUFACTURER'S NAMEPLATES

A. Factory installed manufacturer's nameplates shall be stainless steel with embossed or pre-printed lettering and fastened to the motor frame with Type 316 stainless steel pins. Manufacturer's nameplates shall have stamped on them the motor manufacturer's name, design voltage; number of hertz and phase; horsepower rating; amperage and temperature rise at rated load, full load speed, NEMA code letter, service factor, minimum guaranteed efficiency, model number, AFBMA bearing number, serial number and maintenance manual number in accordance with NEMA MGI-10.40.1.

B. A separate factory installed manufacturer's nameplate shall provide lubrication instructions and a separate nameplate connection diagram for dual voltage motors.

C. Additionally, factory to provide the following information on manufacturer's nameplates or additional manufacturer's nameplates for:
   1. NEMA guaranteed minimum efficiency.
   2. Explosion-Proof motors: Indicate UL frame temperature limit code.
   3. Space heater information.
   4. NEMA MG 1 Over Temperature Protection Type Number.

5. Temperature device rating and alarm and shutdown setpoint information.

D. Thermal Protection:
   1. Provide NEMA Type-1 thermal protection: Two-100-ohm platinum RTDs in each winding.
   2. Provide resistance Temperature Detectors (RTD) wired to separate motor termination box with wiring diagram provide.
   3. Contractor shall provide RTD monitor and transmitter at the motor, as indicated or at the motor controller.
   4. Motor manufacturer shall provide indicated alarm and temperature trip setpoints in the O & M manual.

2.2 CONSTRUCTION

A. Unless specified otherwise, all motors provided under this Section shall have the following features of construction and operation:
   1. Motor voltage, speed and enclosures are specified in the detailed equipment Specifications. Motors furnished with equipment shall comply with this Section.
   2. All motors shall be of the motor manufacturer's premium energy-efficient design, different from manufacturer's standard product through the use of premium materials, design and improved manufacturing process, that reduces motor losses approximately 40 percent from standard efficient designs.
   3. Motor efficiency shall be determined in accordance with NEMA Standard MG1-12.54.1 and guaranteed minimum full load efficiency labeled on motor manufacturer's nameplate in accordance with NEMA Standard MG1-12.54.2 or MG1-10.40.1 below.
   4. All motors shall successfully operate under power supply variations in accordance with NEMA MG1-14.30.
   5. All motors shall be NEMA Design B with torque and starting currents in accordance with NEMA MG1-12.35 and 12.37, except in special applications requiring higher starting torques where NEMA Design C is permitted.
   6. All motors shall have a 1.15 service factor. Polyphase integral horsepower motors shall be sized so that, under maximum load conditions imposed by the driven equipment, for the conditions specified, the motor manufacturer's nameplate rated horsepower and Class B temperature rise will not be exceeded. Motors with a service factor of 1.15 shall be selected for operation within their full load rating without applying the service factor.
   7. Each motor shall be of the speed and horsepower specified or required to properly operate the driven equipment, torque characteristics as required by the drive load and suitable for direct coupling or V-belt drive, as shown on the Drawings and specified herein. Motors shall be designed for full voltage starting, unless otherwise specified.
   8. Frames shall be of corrosion-resistant cast iron with integrally cast feet or bases. End bells, conduit box and cover and bases shall be cast iron, with

precision machined bearing fits, ASTM Type A-48, Class 25 or better. UL approved automatic stainless steel breather drains shall be provided in the lowest part of front and back brackets to allow drainage of condensation on TEFC and explosion proof motors.

9. Each stator core assembly shall consist of stacked lamination made from specially selected electrical sheet silicon steel.

10. Insulation materials shall be non-hygroscopic and meet or exceed Class H (--1--) definition, utilizing materials and insulation systems evaluated in accordance with IEEE 117 classification tests. Motor temperature rating shall not exceed Class B temperature limits as measured by resistance method when the motor is operated at full load at 1.0 service factor continuously in a maximum ambient temperature of 50° C. Windings shall be copper.
11. Rotor cages shall be fabricated copper. Shafts shall be made from carbon steel.
12. Rotors on frames 213T and above shall be keyed shrunk or welded to shaft and rotating assembly dynamically balanced to NEMA limits in accordance with MG1-12.06. Balance weights, if required, shall be secured to the rotor resistance ring or fan blades by rivets. Machine screws and nuts are prohibited. The entire rotating assembly between bearing inner caps shall be coated with a corrosion-resistant epoxy.
13. Bearings shall be ball, open, single row, deep groove, Conrad type, and shall have a Class 3 internal fit conforming to AFBMA Std. 20. For belted duty applications, drive end bearing may be cylindrical roller type. Bearings shall be selected to provide L-10 rating life of 100,000 hours minimum. Calculations shall be based on external loads using NEMA applications limits in accordance with MG1-14.41 and typical sheave weights and internal loads defined by the manufacturer, including magnetic pull and rotating assembly weight.
14. Bearing temperature rise at rated load shall not exceed 60° C. Temperature rise shall be measured by RTD or thermocouple at bearing outer race. Bearing AFBMA identification number shall be stamped on motor manufacturer's nameplate.
15. Motor lubrication system shall consist of a sealed bearing or a grease inlet on motor bracket with capped grease fitting on inlet, grease relief plug 180 degrees from inlet, grease reservoir in bracket and grease reservoir in cast inner cap. Motor shall be greased by manufacturer with a premium moisture resistant polyuria thickened grease containing rust inhibitors and suitable for operation over temperatures from -25° C to 120° C. Vertical motors lubrication system shall be manufacturer's standard oil or grease.
16. All bolt and cap screws shall be of high strength, SAE Grade 5 zinc-plated and chromatic steel. Screwdriver slot fasteners are unacceptable.
17. All motor parts including frame, brackets, fan cover and terminal box shall receive a minimum of two coats of high grade USDA accepted epoxy paint.

Motor assembly shall successfully withstand salt spray tests for corrosion in accordance with ASTM B-117 for 96 hours.

18. All motors shall be painted the same color as the driven equipment.
19. Standard motors shall be provided by the manufacturer of the driven equipment under an assumption of unit responsibility. The Contractor shall assign unit responsibility to the manufacturer for the equipment specified and a certificate of unit responsibility shall be provided.
20. Where shown on the Drawings or Schedules, furnish motors with space heaters to prevent condensation inside the motor enclosure after motor shutdown and maintain the temperature of the winding at not less than 5-degree C above outside ambient temperature. Heaters shall be flexible wraparound type rated 120 volts, single phase, 60 Hertz. The space heater rating in watts and volts shall be noted on the motor manufacturer's nameplate or on a second manufacturer's nameplate. Space heater leads H1 and H2 shall be brought to a separate terminal block or pigtails in the motor conduit box or separate conduit box with a threaded conduit opening

2.3 ADDITIONAL REQUIREMENTS FOR MOTORS LARGER THAN 250 HP

A. General:
   1. Unless otherwise specified, motors over 250 horsepower shall be three phase, squirrel cage, full voltage start induction type. Unless otherwise specified, motors shall have a NEMA MG 1-1.16 design letter B or C torque characteristic as required by the driven equipment's starting torque requirements.

B. Rating:
   1. Unless otherwise specified, motors shall be rated for operation at 460 volts, 3 phase, 60 Hz, and shall be continuous time rated in accordance with NEMA Standard MG 1, Paragraph 10.35.
   2. Motors for variable frequency systems shall not be required to deliver more than 80 percent of the motor's service factor rating by any load imposed by the driven machine at any specified operating condition or any condition imposed by the driven machine's performance curve at maximum operating speed.

C. Enclosure and Insulation:
   1. General: Motors shall be classified as Type 1 (Process) or Type 2 (Explosion proof). Enclosures and insulation systems shall be as specified in the following paragraphs. Temperature rise for all motor types shall not exceed that permitted by Note II, Paragraph 12.42, NEMA MG 1. The insulation shall be non-hygroscopic.
      a. Type 1 Motors (Process): Type 1 motors shall be premium energy efficient motors, totally enclosed, fan cooled. All motors shall have Class H insulation with Class B temperature rise. Motors shall conform

to IEEE 841. All internal surfaces shall be coated with an epoxy paint. Motors shall be rated for corrosive atmosphere duty.

b. Type 2 Motors (Explosion proof): Explosion proof motors shall be UL listed in accordance with UL 674 for Class I, Group D hazardous atmospheres. The motor shall have Class H insulation and shall conform to IEEE 841. Steel frame motors will not be permitted. A UL-approved Type 316 stainless steel breather/drain device shall be provided in the motor drain hole. The motor shall be provided with a frame temperature thermostat which meets the UL frame temperature limit code T2A (280°C). The thermostat shall contain an automatically reset, normally closed contact rated two amperes at 115 volts AC.

D. Motors for Variable Frequency Drives:

1. Motors intended for use with variable frequency drives shall be compatible with the characteristics of the intended variable frequency inverters. Motors shall be Type 1 or Type 2 as specified in the detailed Specification. Insulation for all motors operating with variable frequency drives shall be Class H (--1--) with Class B temperature rise. Variable frequency drive motors shall be premium energy-efficient motors. Motors shall be capable of withstanding a pulse voltage of at least 1750 volts with a rate of rise up to 750V/micro second. The motors shall be certified by the manufacturer as suitable for inverter duty.
2. All motors connected to variable frequency drives shall be equiped with shaft grounding rings. Shaft grounding devices must be factory installed or installed by a reputable motor shop with the expertise in the proper installation of the devices. If the shaft grounding devices are not factory installed, a third party shall be engaged to test the installation to ensure no damaging shaft currents are present.

E. Minimum Manufacturer's Nameplate Efficiency: Motor minimum manufacturer's nameplate efficiency, determined in accordance with IEEE 112B testing procedures, when operating on a sinusoidal power source shall conform to the following for motors 250-500HP. For motors above 500 horsepower, efficiency shall be determined by customized motor specification questionnaire (see NTS) in consultation with the manufacturer:

IEEE STD 841-2001	900 rpm 8-pole	1200 rpm 4-pole	1800 rpm 6-pole	3600 rpm 2-pole
250HP				
600V	93.6	94.1	94.1	94.5
2300/4000V	94.1	94.1	94.1	94.1

300HP				
600V	-	94.1	94.5	94.5
2300/4000V	94.1	94.1	94.1	94.1
350HP				
600V	-	94.1	94.5	94.5
2300/4000V	94.1	94.1	94.1	94.1
400HP				
600V	-	-	94.5	94.5
2300/4000V	94.1	94.1	94.1	94.1
450HP				
600V	-	-	94.5	94.5
2300/4000V	94.1	94.1	94.1	94.1
500HP				
600V	-	-	94.5	94.5
2300/4000V	94.1	94.1	94.1	94.1

F. Vertical Motors:
   1. Unless otherwise specified, vertical motors shall be full voltage with a Type P base specifically designed for vertical installation. Universal position motors are not acceptable. Vertical motors shall have solid shafts, unless otherwise specified. Vertical motors shall conform to either Type 1 or Type 2 motor requirements as specified under Paragraph 2.4.C., above. Thrust bearing rating shall be compatible with the loads imposed by the driven equipment.

G. Conduit Boxes:
   1. CONTRACTOR is cautioned that external conduit boxes on motors shall be sized to accommodate oversized feeder conductors and as shown on the Drawings shall, in any case, not be less than one size larger than NEMA standards. The conduit boxes shall be diagonally split and rotatable in 90 degree steps. A gasket shall be furnished between the conduit box and frame. Motor leads shall be stranded copper wire, Class H or better insulated, non-wicking, with permanent identifications spaced 1-1/2-inches maximum. Clamp type grounding terminals shall be provided in the conduit boxes.

H. Lifting Eyes:
   1. Motors weighing more than 50 pounds shall be fitted with at least one lifting eye.

I. Current Imbalance:
   1. Current imbalance shall not exceed the values tabulated below when the motor is operating at any load within its service factor rating and is supplied by a balanced voltage system.
      a. Under five horsepower: Ten percent
      b. Five horsepower and above: Ten percent
   2. Imbalance criteria shall be based upon the lowest value measured.

2.4 PRODUCT DATA

A. The following information shall be provided for each motor in accordance with the individual equipment specification.
   1. Motor outline, dimensions and weight.
   2. Manufacturer’s general descriptive information relative to motor features.
   3. Where a winding overtemperature device is required, provide a response curve for the temperature device.
   4. Applicable operation and maintenance information specified in Section 01781, Operation and Maintenance Data. Provided overhaul instructions for each motor.

2.5 ACCEPTABLE PRODUCTS

A. The following manufacturer's motors generally meet the class and performance requirements of this specification when furnished with appropriate modifications and additional features as specified:
   1. General Electric Inc.
   2. Emerson US Motors
   3. Siemens

PART 3 - EXECUTION

3.1 GROUNDING AND BONDING

A. Verify the circuit ground cable (green) is identified and connected to the grounding lug terminal in the conduit box.

B. Provide supplementary grounding by installing a bond from the motor frame to the grounding electrode system as indicated on the drawings.

3.2 FIELD TESTING

A. Verify breather/drain fittings have been installed as specified herein.

B. Provide winding insulation resistance testing for motors to be witnessed by owner or engineer before connection is complete. Winding insulation resistance shall be not less than 10-megohm measured with a 1000-VAC megohmmeter at 1-minute at or corrected to 40-degree C.

C. Provide motor phases current imbalance testing to be witnessed by owner or engineer.

+ + END OF SECTION + +

SECTION 11287

STAINLESS STEEL SLIDE GATES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish and install stainless steel slide gates and appurtenances.
   2. Included are stainless steel slide gates, anchorage systems and all appurtenances.
   3. Extent of the equipment on the Stainless Steel Slide Gate Schedule contained in Part 2 of this Section.

1.2 QUALITY ASSURANCE

A. Manufacturer's Qualifications:
   1. Manufacturer shall have a minimum of five years of experience of producing substantially similar equipment and shall be able to show evidence of at least five installations in satisfactory operation for at least five years.
   2. Stainless steel slide gates shall be the product of one manufacturer.

B. Unit Responsibility:
   1. Unit Responsibility shall assigned by CONTRACTOR as specified in Section 01600, General Equipment Provisions, to the individual gate suppliers for the entire gate assembly, including both the equipment provided under this Section and the associated electric actuators provided under Section 11200, 480 Volt Motor-Operated Valve and Gate Actuators. A Certificate of Unit Responsibility shall be provided.

C. Component Supply and Compatibility:
   1. Obtain all equipment included in this Section regardless of the component manufacturer from a single stainless steel slide gate equipment manufacturer.
   2. Stainless steel slide gate equipment manufacturer shall review and approve or shall prepare all Shop Drawings and other submittals for all components furnished under this Section.
   3. All components shall be specifically designed for control of (--1--) service and shall be integrated into the overall equipment design by the stainless steel slide gate equipment manufacturer.

D. Source Quality Control:
   1. Shop Tests:
      a. Test each stainless steel slide gate fully assembled in the vertical position for proper seating.
      b. Fully open and close gate disc in its guide system to ensure that it operates freely.
      c. Operate and test floor stands, bench stands and electric operator in accordance with this Section and Section 11200, 480 Volt Motor-Operated Valve and Gate Actuators to ensure proper assembly and operation.

E. Reference Standards: Comply with applicable provisions and recommendations of the following, except as otherwise shown or specified.
   1. ASTM A 276, Specification for Stainless Steel Bars and Shapes.
   2. ASTM B 584, Specification for Copper Alloy Sand Castings for General Application.

1.3 SUBMITTALS

A. Certificate of Unit Responsibility attesting that CONTRACTOR has assigned, and the supplier accepts unit responsibility in accordance with the requirements of this Section and Section 01600, General Equipment Provisions, including both the equipment provided under this Section and the associated electric actuators provided under Section 11200, 480 Volt Motor-Operated Valve and Gate Actuators. No other Submittal material will be reviewed until the certificate has been received and conforms to the specified requirements.

B. Shop Drawings: Submit for approval the following:
   1. Comply with the requirements of Section 01332, Shop Drawing Procedures.
   2. Fabrication, assembly and installation diagrams.
   3. Manufacturer's literature, illustrations, specifications and engineering data.
   4. Setting drawings, templates, and directions for the installation of anchor bolts and other anchorages.
   5. Wiring diagrams for electric motor operators.

C. Shop Test Results:
   1. Submit results of the required shop tests.

D. Field Test Results:
   1. Submit a written report giving the results of the field tests required.

E. Operation and Maintenance Manuals:
   1. Submit complete installation, operation and maintenance manuals including, test reports, maintenance data and schedules, description of operation and spare parts information.

2. Furnish Operation and Maintenance Manuals in conformance with the requirements of Section 01781, Operation and Maintenance Data.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Deliver materials to the site to ensure uninterrupted progress of the Work. Deliver anchor bolts and anchorage devices, which are to be embedded in cast-in-place concrete in ample time to not delay the Work.

B. Handle all stainless steel slide gates and appurtenances properly, in accordance with manufacturer's recommendations. Stainless steel slide gates which are distorted or otherwise damaged will not be acceptable. Protect all bolt threads and ends from damage and corrosion.

C. Store materials to permit easy access for inspection and identification. Keep stainless steel members off the ground using pallets, platforms or other supports. Protect stainless steel members and packaged materials from corrosion and deterioration.

D. Store all mechanical equipment in covered storage off the ground, and prevent condensation.

PART 2 - PRODUCTS

2.1 SERVICE CONDITIONS

A. General: Design equipment to be suitable for the process and service conditions described below and in the Stainless Steel Slide Gate Schedule.
   1. Design stainless steel slide gates to safely withstand conditions listed in the Stainless Steel Slide Gate Schedule.
   2. Stainless steel slide gates shall be substantially watertight with leakage less than 0.5 gpm per foot of seating perimeter at design head.
   3. Manual operators shall turn right to close, unless otherwise specified. Operators shall indicate the direction of operation.
   4. Bolts, studs, cap screws, and adjusting screws shall be of ample section to withstand the force created by operation of the gate under a full head of water.
   5. Downward opening stainless steel slide gates shall be capable of being lowered to an elevation below the invert of the channel or opening.
   6. Stainless steel slide gates shall open to not less than 6-inches above the maximum water level in the channel in which they are installed.

2.2 FABRICATION

A. Materials of Construction:

1. Stainless Steel: For frame, slide, rail and yoke, ASTM A 276, Type 2205 duplex stainless steel. All metal for stainless steel slide gate parts shall have a minimum thickness of 1/4-inch.
2. Bronze Casting: For operating nut, thrust nut and lift nut; ASTM B 584 Alloy 865.
3. All bolts, studs, cap screws and adjusting screws shall be of Type 2205 duplex stainless steel.
4. Bolts and nuts shall have hexagon heads.
5. Gasket material and installation shall conform to manufacturer's recommendations.

B. Disc:
1. Fabricate the slide or disc of ASTM A 276, Type 2205 duplex stainless steel plate reinforced with structural shapes attached by welding.
2. Provide reinforcing to limit deflection under full head to not more than 1/360 of the span.
3. Extend reinforcing ribs into the guides overlapping the seating surface of the guide.
4. Weld stem mounting guides to the disc.

C. Disc Guides:
1. Guides shall be of Type 2205 duplex stainless steel incorporating a sandwich type construction using plates and structural angles.
2. Guides shall be designed for maximum rigidity as columns to take the thrust developed during the gate operation under maximum head.
3. Guides shall extend beneath the opening a sufficient amount to support the disc in the fully open or closed position.

D. Stem:
1. Operating stems shall be of Type 2205 duplex stainless steel and designed as specified below.
2. Design stem to transmit in compression at least 2-1/2 times the rated output of the operating mechanism with a 80 pound effort on the crank or handwheel. Determine the critical buckling load using the Euler column formula, using C = 2. Where hydraulic cylinder lifts are used, the stem design force shall not be less than 1.25 times the output thrust of the hydraulic cylinder with a pressure equal to the maximum working pressure of the hydraulic fluid supply. Where electric motor driven lifts are used the stem design force shall not be less than 1.25 times the output thrust of the unit in the stalled motor condition.
3. Stems shall have a slenderness ratio (L/R) less than 200.
4. Threaded portion of the stem shall have machined cut threads of the Acme type. Join stems of more than one section by stainless steel couplings threaded and keyed, or bored and pinned to the stems. All threaded and keyed couplings of the same size shall be interchangeable. Provide rising stems with an adjustable stop collar on the stem.

5. Connect the stem to the disc by means of a bolted connection.

E. Yoke (For Self Contained Type Gates):
1. Furnish tops of the extended guides with a yoke for mounting of the lifting device.
2. Construct the yoke of structural shapes of sufficient strength to take the full thrust created by operating the gate under the maximum specified head.
3. Attach the yoke to the framework by bolting or welding so as to permit removal of the gate slide and stem.

F. Lower Seals:
1. Mount a specially shaped resilient neoprene seal on the bottom of the disc to provide flush-bottom closure for stainless steel slide gates. As an alternate, a poured urethane seal shall be mounted in the invert of the frame to form a flush bottom seal.
2. Shape of the seal shall produce a seating surface having a minimum width of 3/4-inch, and the seal will extend beyond the seating surface of the frame.
3. Vertical face of the seal shall be in contact with the seating surface of the guide to provide a proper seal at the corners.

G. Side and Upper Seals:
1. Side and upper seals shall be fabricated from ultra high molecular weight (UHMW) polyethylene or UHMW polymer. UHMW bearing strips shall be mechanically retained to lock seat in place.

H. Packing Glands:
1. Provide downward opening stainless steel slide gates in covered tanks with a suitable packing gland to prevent the escape of air from the tanks through the stem sleeve.

I. Product and Manufacturer: Provide one of the following:
1. Rodney Hunt Company.
2. Waterman Industries.
3. H. Fontaine Ltd.

2.3 APPURTENANCES

A. Stem Guides:
1. Guides shall be adjustable in two directions and shall be spaced so that stems have a maximum unsupported length of 84-inches.
2. Anchor bolts for stem guides shall be Type 2205 duplex stainless steel.

B. Anchor Bolts:
1. Provide Type 2205 duplex stainless steel anchor bolts as required for stem guides, floorstands, and all equipment or appurtenances which must be secured to concrete

walls or floors. Anchor bolts shall be of ample size and strength for the purpose intended, and shall be furnished by the manufacturer. Anchor bolts shall be hooked, and provided for direct embedment during placement of concrete. Anchor bolts shall conform to the requirements of Section 05051, Anchor Bolts, Toggle Bolts and Concrete Inserts.

C. Stem Cover:
1. Furnish all stems with a clear polycarbonate or butyrate plastic pipe stem cover. Covers shall be furnished with a cast aluminum adaptor for mounting covers to floor stands. Stem covers shall be designed and furnished with gasketing and breathers to eliminate water intrusion into operators and condensation within the covers.
2. Engrave the covers with legible markings showing as a minimum the gate position at 1/4 open, 1/2 open, 3/4 open and full open.

D. Manual Operators:
1. Manual operation shall be by handwheel or crank operated floorstand or benchstand as shown on the Drawings and specified.
2. Handwheel-operated type shall be without gear reduction and crank-operated type will have either a single or double gear reduction, as required. Each type shall be provided with a threaded cast manganese bronze lift nut to engage the operating stem.
3. Provide anti-friction bearings to properly support both opening and closing thrusts.
4. Stands shall operate the gates under the specified operating head with not greater than a 40-pound pull on the crank or handwheel.
5. All components shall be totally enclosed in a cast iron weather- proof housing. Provide positive mechanical seals to exclude moisture and dirt and prevent leakage of lubricant out of the unit.
6. Provide lubricating fittings for all gears and bearings.
7. Stands shall include a cast iron pedestal designed to position the input shaft approximately 36-inches above the operating floor. An arrow with the word "OPEN" shall be permanently attached or cast on the floorstand indicating the direction of rotation to open the slide gate.
8. Removable cranks shall be cast iron with a revolving brass grip. Removable handwheel shall be fabricated steel designed for rough treatment and minimum weight.
9. For self contained type stainless steel slide gates, the distance between handwheel or crank operator and the operating floor shall be 36-inches minimum and 48-inches maximum.
10. Crank-operated gates shall be provided with nut-operator drives as noted on Stainless Steel Slide Gate Schedule.
11. Operators shall be furnished with a limit switch to indicate fully closed position, where shown on the Drawings.
12. Provide mechanical stops adjustable ±five degrees at each end of travel.

E. Electric Operators:
   1. Electric motor operators shall be furnished as shown on the Slide Gate Schedule, in accordance with the requirements of Section 11200, 480 Volt Motor-Operated Valve and Gate Actuators.

F. Identification: Identify each stainless steel slide gate with a stainless steel manufacturer's nameplate stamped with the approved designation as shown in the Stainless Steel Slide Gate Schedule, below. Manufacturer's nameplate shall be permanently fastened to the gate at the factory.

2.4 SURFACE PREPARATION AND PAINTING

A. Clean, prime coat, and finish coat ferrous metal surfaces of equipment in the shop in accordance with the requirements of Section 01600, General Equipment Provisions, and Section 09900, Painting.

B. Coat machined, polished and non-ferrous surfaces bearing surfaces and similar unpainted surfaces with corrosion prevention compound which shall be maintained during storage and until equipment begins operation.

C. Surface preparation and painting shall conform to Section 09900, Painting.

D. Certify, in writing, that the shop primer and coating system conforms to the requirements of Section 09900, Painting.

2.5 SPECIAL TOOLS

A. Furnish two sets of any special tools required for normal operation and maintenance.

2.6 LUBRICANTS

A. Furnish Food grade oil and grease meeting NSF 61 for water applications as required for initial operation. Use products recommended by the manufacturer.

2.7 SLIDE GATE SCHEDULE

A. Schedule 11287 "Stainless Steel Slide Gates" is the Stainless Steel Slide Gate Schedule. Conform to type, size, operation and other data specified, unless otherwise approved by ENGINEER.

B. Provide all stainless steel slide gates as shown on the Drawings and listed in the Stainless Steel Slide Gate Schedule.

C. Schedule Abbreviation:
   1. Type:
      a. EF - Embedded Frame.
      b. SM - Surface Mounted Frame.
      c. WG - Downward Opening Weir Gate.
   2. Operator Type:
      a. CO - Crank Operated.
      b. HW - Handwheel.
      c. EO - Electric Operated.

D. The seating and unseating design head as stated in the Stainless Steel Slide Gate Schedule is based on the head measured to the centerline of the gate in its closed position.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install stainless steel slide gate equipment in accordance with manufacturer's instructions and recommendations.

B. Brace guides and frames during placement of concrete.

C. Set anchor bolts in accordance with approved Shop Drawings and manufacturer's recommendations.

D. Provide minimum of 1-inch of non-shrink grout below all floorstands.

E. Adjust all parts and components as required to provide correct operation.

3.2 START-UP AND FIELD TESTS

A. After CONTRACTOR and ENGINEER have mutually agreed that the equipment installation is complete and ready for continuous operation, CONTRACTOR and a qualified field service representative of the manufacturer shall conduct a functional field test and a leakage test of each stainless steel slide gate in the presence of ENGINEER to demonstrate that each stainless steel slide gate furnished will function correctly and that maximum permissible leakage is not exceeded.
   1. Functional Tests:
      a. Each stainless steel slide gate with appurtenances shall be field tested. Tests shall demonstrate to ENGINEER that each part and all parts together function in the manner intended. All necessary testing equipment and manpower shall be provided by CONTRACTOR at his expense. OWNER will furnish all power, and incidental material and labor required for the tests.

2. Leakage Tests:
   a. Maximum permissible leakage shall be in accordance with the requirements of Paragraph 2.1, above. Excess leakage shall be reduced to meet specified requirements by adjusting the gate, or replacement will be required.
3. For electric operated gates, perform all field tests and adjustments required under Section 11200, 480 Volt Motor-Operated Valve and Gate Actuators.
4. In the event that the manufacturer is unable to demonstrate to ENGINEER that his equipment meets the requirements of the tests, the deficient equipment will be rejected; adjustments and/or modifications made and retest the equipment as often as necessary to meet the specified requirements. No separate payments shall be made for adjustments and/or modifications.

3.3 MANUFACTURER'S SERVICES

A. A factory trained representative shall be provided for installation supervision, start-up and test services and operation and maintenance personnel training services. The representative shall make a minimum of (--1--) visits, minimum (--2--) hours on-site for each visit, to the site. The first visit shall be for assistance in the installation of equipment. The second visit shall be for checking the completed installation and start-up of the system. The third visit shall be as described under Section 01821, Instruction of Operations and Maintenance Personnel. Manufacturer's representative shall test operate the system in the presence of the ENGINEER and verify that the stainless steel slide gates conform to requirements. Manufacturer's representative shall revisit the job site as often as necessary until all trouble is corrected and the installation is entirely satisfactory.

B. All costs, including travel, lodging, meals and incidentals shall be considered as included in the CONTRACTOR'S bid price.

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SCHEDULE 11287 STAINLESS STEEL SLIDE GATES	
Location:	Lift Station No 66 Wet Well
1. Designation	SSG-1
2. Size (Lin x Win):	42” x 42”
3. Quantity:	3
4. Type:	EF
5. Design Head: a. Seating Range (ft): b. Unseating Range (ft):	 3 – 24 3 – 24
6. Operator Type:	HW
7. Tag Nos.	SLUG-100A, SLUG-100B, SLUG-105

+ + END OF SECTION + +

SECTION 11318

END SUCTION SUBMERSIBLE PUMPS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals required to install pre-purchased wastewater submersible, end suction centrifugal pumps complete and operational with motors, alarm equipment, alternator and accessories as shown on the Drawings and specified. Anchor bolts shall comply with section 05051 and 05501.

1.2 QUALITY ASSURANCE

A. Manufacturer's Qualifications:
   1. Manufacturer shall have a minimum of five years of experience of producing substantially similar equipment, and shall be able to show evidence of at least five installations in satisfactory operation for at least five years.

B. Reference Standards: Comply with applicable provisions and recommendations of the following, except as otherwise shown or specified.
   1. Standards of the Hydraulic Institute.
   2. National Electrical Code (NEC) current adoption.
   3. City of Phoenix – Amendments to the National Electrical Code.
   4. Standards of National Electrical Manufacturers Association.
   5. Institute of Electrical and Electronic Engineers.
   6. American National Standards Institute.
   7. Standards of American Water Works Association.

C. Shop Tests:
   1. Pump casings shall be hydrostatically tested to twice the discharge head or 1-1/2 times the shutoff head whichever is greater.
   2. Running Test: Pump assembly shall be operated from zero to maximum capacity as shown on the approved curve. Results of the test shall be shown in a plot of test curves showing head, flow, horsepower, efficiency, and current. Readings shall be taken at a minimum of five evenly spaced capacity points including shut-off, design point and minimum head for which pump is designed to operate.
   3. Each test shall be witnessed by a Registered Professional Engineer in the state of Arizona, who may be an employee of the manufacturer. The Registered Professional Engineer shall sign and seal all copies of curves and shall certify

that hydrostatic tests were performed. Tests shall be conducted in conformance with the methods described in Section A6 of AWWA E101.

4. Pumps shall not be shipped until the ENGINEER has approved the test reports.

D. Unit Responsibility: Assign Unit Responsibility as specified in Section 01600, General Equipment Provisions, to the manufacturer or supplier for the equipment specified in this Section. A Certificate of Unit Responsibility shall be provided.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
1. Manufacturer's literature, illustrations, specifications and engineering data including: dimensions, materials, size, weight, performance data and pump curves showing overall pump efficiencies, flow rate, head, brake horsepower, motor horsepower, speed and shut-off head.
2. Shop Drawings Showing: Fabrication, assembly, installation and wiring diagrams.
3. Guarantee.
4. Motor tests and data as described in PART 2 below.
5. Submit Shop Test results conforming to Paragraph 1.2.C., above.

B. Operation and Maintenance Manuals:
1. Submit complete installation, operation and maintenance manuals including test reports, maintenance data and schedules, pump curves, description of operation and spare parts information.
2. Furnish operation and maintenance manuals in accordance with the requirements of Section 01781, Operation and Maintenance Data.

1.4 WARRANTY

A. The pump manufacturer shall warranty the units being supplied to the OWNER against defects in workmanship and material for a period of five years under normal use, operation, and service. The warranty shall cover parts and labor and shall be in printed form and apply to all similar units.

PART 2 - PRODUCTS

2.1 SERVICE CONDITIONS

A. Pumps shall be submersible end suction centrifugal wastewater type. Pumps shall be designed for operation under complete submersion, partial submersion and also under dry conditions. Each pump shall be specially designed, constructed, and installed for the service intended and shall comply with the design conditions listed below.

B. Design Conditions:

Location (Tag IDs):	Lift Station No. 66 (Pump P-101, P-102, P-103, and P-104)
Service:	Wastewater
Quantity of Pumps Required:	4
Design Flow: gpm	5,555
Design TH: ft.	210
Min. Shut-off Head: ft.	100
Min. Hydraulic Efficiency at Design: %	75
Max Motor HP: HP	470
Max. Speed: rpm	1,200
Sphere Diameter: in.	3
Nominal Discharge Size: in.	12
Flow at 2nd Design Point: gpm	4,000
TH at 2nd Design Point: ft.	228
Flow at 3rd Design Point: gpm	9,000
TH at 3rd Design Point: ft	165
Shut off Head:	295

Lift Station No. 66 SYSTEM CURVE TABLE				
	C-Value System Curve (110) Single Pump in 1 x Forcemain		C-Value System Curve (130) Single Pump in 2 x Forcemains	
	Flow, gpm	Head, ft	Flow, gpm	Head, ft
System Point No. 1	2,000	95	2,000	84
System Point No. 2	4,000	145	4,000	96
System Point No. 3	6,000	225	6,000	118
System Point No. 4	7,000	275	7,000	130
System Point No. 5	8,000	330	8,000	147

2.2 DETAILS OF CONSTRUCTION

A. Pump Materials and Construction: The pumps shall be designed to pump wastewater as specified. The pumping units shall automatically and positively mate with its discharge piping permanently when lowered into place. The pumps shall be removable for inspection or service requiring no bolts, nuts or other fastenings to be disconnected. Each pump shall be fitted with a Type 2205 duplex stainless steel chain of adequate strength and length for pump removal. A Type 2205 duplex stainless steel lifting safety type hook or bail shall be provided at both ends of the chain. The manufacturer shall provide guide rail brackets, base elbow, self-seating flange and disconnect and other items required for a guide rail type removal system. The pumps, with appurtenances and cable, shall be designed for continuous operation under submergence, without leakage, in water to a nominal depth of 33 feet.

1. Stator casing, oil casing, sliding bracket, volute and impeller shall be close grained grey cast iron ASTM A-48, Class 35B.
2. Impeller shall be enclosed single vane non-clog, dynamically balanced. Impeller shall be high efficiency and integral to the cooling system driven by the pump shaft. Wear ring shall be Hard-Iron® in accordance with ASTM A-532 Alloy A that consists of 25% chrome cast iron.
3. External Hardware: All bolts, nuts and cap screws shall have hexagon heads and be of Type 316 stainless steel.
4. Shaft: Type AISI 431 stainless steel.
5. The seal shall require neither maintenance nor adjustment and shall be easily replaceable. Shaft seal shall be water flushed mechanical type as manufactured by one of the following:
   a. John Crane Co., double or durametallic RXO double.
   b. Seal face material to be silicon carbide vs. silicon carbide.
   c. Rotating metal parts to be Type 316 stainless steel.

d. All O-rings for mechanical seals shall be EPDM, or equal.
e. Provide needle valve and pressure gauge on stuffing box inlet. Pipe flushing water to approved drain location.

6. Coating: All surfaces in contact with wastewater shall be protected with two layers of Tankguard-412 with a thickness of 8miles DFT per layer and in accordance with Section 09900, Painting. Blast surfaces to SP 10 near white metal cleaning prior to coating.
7. Bearings: Anti-friction, grease or oil lubricated with a minimum B-10 life of 100,000 hours.
8. Stainless steel manufacturer's nameplate giving the model and serial number, rated capacity, head, speed and all other pertinent data shall be attached to the pump.
9. Guide rails shall be Type 2205 duplex stainless steel.
10. Each pump shall be provided with a minimum of 50 feet of nylon line connected to a short length of high tensile, proof tested stainless steel chain. The nylon line shall be sized to sustain all tensile stresses during lifting of the pump. The stainless steel chain shall be connected to the lifting eye. A steel forged grip-eye shall be provided separately to connect the end of the lifting chain to the pump.
11. Access Frames and Covers: Pumping units shall be furnished with rectangular 6061 T6 aluminum alloy access frames and covers complete with heavy duty Type 2205 duplex stainless steel hinges and locking hasp. Covers shall be designed for 300 pound per square foot live loading and shall have safety checked or abrasive, nonslip surfaces. Opening sizes shall be as shown on the Drawings. The access frames and covers shall conform to the requirements of Section 05581, Floor Access Hatch Covers.

B. Motors:
1. Motors shall conform to the requirements of Section 11000, Electric Motors.
2. Motors shall be NEMA B design, induction type with a squirrel cage rotor, shell type design, housed in an air filled, watertight chamber. The stator windings shall be insulated with moisture resistant Class H insulation rated for 180°C (356 °F). The stator shall be insulated by the current-UV-dip impregnation method using Class H monomer-free polyester resin resulting in a winding fill factor of at least 95%. The stator shall be heat-shrink fitted into the cast iron stator housing. The use of multiple step dip and bake type stator insulation process is not acceptable. The use of bolts, pins or other fastening devices requiring penetration of the stator housing is not acceptable.
3. The motor shall be inverter duty rated in accordance with NEMA MG1, Part 31. Power shall be 460 Volts, 60 Hz, and 3 phase. The motor shall be specifically designed for submersible pump usage and designed for continuous duty pumping media of up to 40°C (104 °F) with an 80°C temperature rise and capable of at least 15 evenly spaced starts per hour.
4. Cable entry shall be isolated with an internal terminal board.
5. Pump and motor shall be designed for continuous and intermittent operation up to twelve starts per hour in a non-submerged condition without damage.

6. Motors shall be non-overloading for the entire pump operating curve.
7. Pump motor cable shall be designed for submersible duty and shall be indicated by code or legend permanently applied to cable. Cable and sizing shall conform to Phoenix Electrical Code for pump motors and shall be supplied in sufficient length to extend continuously, without splices, from the pump to the pump control panel. The power cable entry assembly shall be stainless steel and shall be provided with a strain relief element to inhibit leakage in the event the cable is pulled. Motor power cords shall meet the requirements of the Mine Safety and Health Administration for trailing cables. Motor power cords shall be suitable for direct burial.
8. Motor horsepower shall be adequate so that the pump is non-overloading throughout the entire pump performance curve from shutoff through run-out.
9. Each pump/motor shall be equipped with an integral, closed-loop motor cooling system. The motor cooling jacket shall encircle the stator housing and shall be of Type 304 stainless steel. The closed-loop motor cooling system shall provide heat dissipation for the motor regardless of whether the motor unit is submerged in the liquid media or surrounded by air in a dry-pit installation. The cooling liquid shall pass about the stator housing in the closed loop system between the motor housing and close-fitting guide sleeve in turbulent flow providing for superior heat transfer. The cooling system shall have one fill port and one drain port integral to the cooling jacket. The cooling system shall provide for continuous pump operation in liquid or ambient temperatures of up to 50 °C (122 °F) in accordance with NEMA standards. Operational restrictions that limit the ambient or pumped liquid temperatures at levels less than 50 °C are not acceptable.
10. Cable entry shall be isolated with an internal terminal board.
11. Pump and motor shall be designed for continuous and intermittent operation up to 15 starts per hour in a non-submerged condition without any damage.
12. Motor thrust bearings shall be designed for continuous thrust loads under all conditions of pump operation from zero head to shut-off. The anti-friction bearings shall be rated for a B-10 life of 100,000 hours.
13. Motor Sensors:
    a. Each pump motor shall be equipped with a minimum of three thermal sensors embedded in the stator windings and wired to the control panel for supplemental motor protection.
    b. Leakage sensor in lower part of stator housing shall be wired to leads in the junction chamber.
14. Motors shall have built-in thermal overload protection.
15. Motor Tests and Data:
    a. For each motor furnish an inspection report for the motor or for a previously manufactured electrically duplicate motor which was tested. Provide the following minimum data:
        1) Running current.
        2) Locked rotor current.
        3) Winding resistance measurement.

4) High potential test.
5) Bearing inspection.

C. Accessory Equipment:
1. Provide the following accessories for each pump as required for a complete installation.
a. Anchor Bolts: Type 2205 duplex stainless steel.
b. Guide Bar Brackets, Upper: Type 2205 duplex stainless steel.
c. Guide Bar Brackets, Intermediate: Type 2205 duplex stainless steel.
d. Safety Chain Hook: Type 2205 duplex stainless steel.
e. Cable Holder and Support Grip: Type 2205 duplex stainless steel.
f. Discharge Elbow: Epoxy-lined and epoxy-coated Ductile iron coated per Section 09900, Painting.

D. Controls:
1. Pumping units shall be controlled with liquid level sensors with sufficient length of electrical cable. Level sensors shall be of the sealed mercury switch non-floating, displacement type.
2. Electrical Controls: Furnish and install an automatic pump control center in a NEMA 4X enclosure for operation on a 480 Volt, 3 phase, 60 Hertz electrical power. Each pumping unit shall be provided with an individual disconnect switch, three phase overload protection with manual reset and a magnetic contactor. A 120 volt control circuit transformer with disconnect and overload protection shall be included. Provide an automatic electrical sequence for multi-pumping units.

E. Monitoring Equipment:
1. General:
a. Provide power and control cables and motor protective control devices as specified in Paragraph 2.2.B., above, and in Paragraph 2.2.E.2., below.
b. Instrumentation and control system operational functional requirements relative to the pump applications are shown on the Drawings and specified in applicable Sections in Division 17000.
2. Motor Protective Control Devices:
a. For each pump motor assembly:
1) Provide a solid state monitoring relay with SPDT dry contact closure control outputs for:
a) Stator winding overtemperature.
b) Stator housing leakage sensor.
2) Relays shall be mounted in control panel by others.

F. Product and Manufacturer: Provide one of the following:
1. Flygt Corporation, Model 3312/866 3~670.
2. Approved Equal.

2.4 SPARE PARTS

A. Each pump shall be furnished with a manufacturers repair kit that shall include as a minimum the following:
   1. One set of mechanical seals for each pump.

B. Spare parts shall be packed in sturdy containers with clear indelible identification markings and shall be stored in a dry, warm location until transferred to the OWNER at the conclusion of the Project. Comply with the requirements of Section 01783, Spare Parts and Maintenance Materials.

2.5 SURFACE PREPARATION AND PAINTING

A. Pumps, motors, drives, frames, baseplates, appurtenances, etc., shall receive shop primer and shop finish coating conforming to the requirements of Section 09900, Painting. If any damage to the paint system occurs, the equipment shall be repainted as directed by the ENGINEER.

B. Surface preparation and painting shall conform to the requirements of Section 09900, Painting.

C. All gears, bearing surfaces, machined surfaces and other surfaces which are to remain unpainted shall receive a heavy application of grease or other rust-resistant coating. This coating shall be maintained during storage and until the equipment is placed into operation.

D. Certify, in writing, that the shop primer and shop coating system conforms to the requirements of Section 09900, Painting.

PART 3 - EXECUTION

3.1 INSPECTION

A. Inspect all equipment immediately upon delivery to site. If damaged, notify ENGINEER and manufacturer immediately.

B. Make adjustments required to place system in proper operating condition. Do not install damaged equipment until repairs are made in accordance with manufacturer's written instructions and approved by the ENGINEER. Only minor repair work shall be permitted in the field. All other damaged items shall be sent to factory for repair or replacement.

3.2 START-UP AND TEST

A. Manufacturer's representative shall check and approve the installation before operation. Manufacturer's representative shall field test and calibrate the equipment to assure that the system operates to the OWNER'S satisfaction.

B. Make adjustments required to place system in proper operating condition. Field test and calibrate the equipment to assure that the system operates in accordance with these Specifications and to the satisfaction of the ENGINEER.

C. After completion of installation, the system shall be completely tested to ensure compliance with the operating requirements as specified, indicated on the Drawings and in accordance with Section 01752, Equipment and System Startup and Performance Testing.

D. All equipment will be given running tests by CONTRACTOR at the job site following installation of the equipment and controls. Should the tests indicate any malfunction, make any necessary repairs and/or adjustments. Such tests and adjustments shall be repeated until, in the opinion of the ENGINEER, the installation is complete and the equipment is functioning properly and accurately, and is ready for permanent operation.

3.3 MANUFACTURER'S SERVICES

A. A factory trained representative shall be provided for installation supervision, start-up and test services and operation and maintenance personnel training services. The representative shall make a minimum of three site visits, minimum 8 hours on-site for each visit, to the site. The first visit shall be for assistance in the installation of equipment. The second visit shall be for checking the completed installation and start-up of the system. The third visit shall be as described under Section 01821, Instruction of Operations and Maintenance Personnel. Manufacturer's representative shall test operate the system in the presence of the ENGINEER and verify that the pumps conform to requirements. Manufacturer's representative shall revisit the job site as often as necessary until all trouble is corrected and the installation is entirely satisfactory.

B. All costs, including travel, lodging, meals and incidentals, shall be considered as included in CONTRACTOR'S bid price.

+ + END OF SECTION + +

SECTION 13126

PACKAGED BIOFILTER ODOR CONTROL SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, equipment, materials, and incidentals as required to furnish, install, check, calibrate, test, document, start-up, and place in satisfactory operation the Odor Control System as shown on the Drawings and as specified.
   2. The Odor Control System shall include, but not be limited to the following:
      a. Foul air fan.
      b. Grease filter.
      c. Soil biofilter media and containment liner.
      d. Interconnecting piping, ductwork, fittings, accessories and supports from covered source through exhaust stack.
      e. Dampers, motor starters and disconnects, gauges, and instrumentation and controls, as specified herein.
      f. Spare parts specified.

B. General:
   1. Descriptions contained hereinafter are for guidance and to show the functions desired. They do not describe or specify all components to interface equipment. All parts and equipment necessary to meet functional requirements shall be provided and fit within the dimensions and configuration shown on the Drawings.
   2. The mechanical, structural, instrumentation and electrical design has been based on an Biofilter Odor Control System of a single manufacturer. The cost of any changes and modifications to mechanical, structural, instrumentation or electrical facilities necessary to adapt alternate equipment to the layout and design shown shall be borne by CONTRACTOR. Clearances shown on the Drawings shall be maintained. Any such proposed changes or modifications are subject to review and acceptance by the ENGINEER in accordance with the Special Provisions.
   3. Complete responsibility for the proper operation and functions of the Odor Control System herein specified, belongs to CONTRACTOR. Responsibility for coordination of all interfaces with oher contractors to achieve the required Odor Control System operation belongs to CONTRACTOR.
   4. Electrical conduit and wiring between all integral odor scrubber equipment shall be furnished and installed. Conduit shall be PVC coated galvanized rigid conduit and shall conform to the requirements of Section 16131, Rigid Conduit.

5. In this Section the words FRP pipe and duct are used interchangeably as are vessel and tank
6. Some equipment will require modification from the manufacturer's standard to meet the Specifications.
7. When two or more units of equipment for the same purpose are required they shall be the product of one manufacturer.
8. All fasteners (nuts, bolts and washers) used for the Odor Control System shall be of Type 316 stainless steel, except that fasteners in direct contact with sodium hypochlorite solution shall be of Hastelloy-C.
9. The panels controls shall be furnished in accordance with the requirements as shown on the Contract Drawings, and as specified in Division 17000, Sections 17051 – Computer Control System Process Control Descriptions, 17052 – Process Control System Primary Sensors and Field Instruments, 17053 – Process Control System Instrument Index, 17226 – Process Control System I O List, and 17260 – Control Panels. All panel enclosures shall conform to the requirements of specification 16050 – General Provisions.
10. Odor Control Equipment outdoor areas are considered corrosive areas. All mechanical and electrical equipment and material shall conform to NEMA 4X, non-metallic requirements. Mounting hardware shall be Type 316 stainless steel including fasteners and unistrut.
11. All components of each Odor Control System shall be shop primed and shop finish coated conforming to the requirements of Section 09900, Painting.
12. Comply with the requirements of Section 01413, CONTRACTOR'S HAZARDOUS MATERIALS MANAGEMENT PROGRAM. Stencil CONTRACTOR'S company name on drums of hazardous chemicals that are on-site. If CONTRACTOR is in noncompliance with respect to hazardous materials handling, the OWNER can withhold payments to CONTRACTOR.
13. Coordinate with Section 01143, Coordination with OWNER'S Operations.

1.2 QUALITY ASSURANCE

A. Scrubber System Manufacturer's Qualifications:
   1. Manufacturer shall have a minimum of five years experience of producing substantially similar biofilter equipment and shall be able to show evidence of at least five installations, of the same size and type, in satisfactory operation for at least five years.

B. When two or more units of equipment for the same purpose are required, they shall be the product of one manufacturer.

C. Inspection and Testing Requirements: The visual inspection of the equipment shall comply with ASTM D 2563, Visual Acceptance Level II.

D. Ductwork Manufacturer's Qualifications:

1. Engage a single firm, with undivided responsibility for performance and other requirements and components of the above grade and below grade ductwork.
2. Engage a firm, which can show successful experience in the fabrication and erection of ductwork systems of scope and type similar to the required Work.

E. Installer Qualifications:
1. Engage a single installer with undivided responsibility for performance and other requirements who is regularly engaged in ductwork installation and with experience in the installation of the types of materials required; and who agrees to employ only tradesmen with specific skill and experience in this type of Work. Submit name and qualifications to ENGINEER.

F. Requirements of Regulatory Agencies: Comply with the applicable provisions of regulatory agencies below and others having jurisdiction.
1. Local and State Building Codes and Ordinances.
   a. The BOCA National Building Code.
   b. Phoenix Mechanical Code.
   c. Phoenix Building Code.
2. Underwriters' Laboratories, Incorporated.
3. National Fire Protection Association.

G. Products used in the Work of this Section shall be produced by manufacturers regularly engaged in the production of such items and have a successful history of product acceptability, as interpreted by ENGINEER.

H. Responsibilities:
1. In order to centralize responsibility, it is required that all equipment provided under this Section be obtained from a single supplier or manufacturer who shall assume full responsibility for the completeness of the system. The supplier or manufacturer shall be the source of information on all equipment furnished regardless of the manufacturing source of that equipment.
2. The sole responsibility for proper operation of the Odor Control Systems shall rest with CONTRACTOR.
3. Unit Responsibility: Assign Unit Responsibility as specified in Section 01600, General Equipment Provisions, to the manufacturer or supplier for the equipment specified in this Section. A Certificate of Unit Responsibility shall be provided.

I. Listing, labeling or marking, as conforming to the Standards of Underwriter's Laboratories, Inc., American National Standards Institute, Inc., United States Bureau of Mines, or other nationally recognized testing organization approved by Code, on various pieces of equipment furnished shall be prima facie evidence of conformity with the approved standards for safety to life and property.

J. Materials Testing:
   1. Material employed in items fabricated of fiberglass reinforced plastic shall be capable of withstanding maximum calculated stresses that may occur during fabrication, installation and continuous operation, with allowance for an adequate safety factor. To confirm materials properties, tests shall be conducted by an independent, qualified testing laboratory on representative material samples in accordance with the following latest revision of ASTM standards:
      a. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE).
      b. Sheet Metal and Air Conditioning Contractors National Association (SMAC-NA).
         1) HVAC Duct Construction Standards.
         2) Fire Damper Guide for Air Handling Systems.
      c. ANSI B16.1, Cast Iron Pipe Flanges and Flanged Fittings, Class 125.
      d. ANSI B16.5, Pipe Flanges and Flanged Fittings, Steel Nickel Alloy and Other Special Alloys.
      e. ANSI B73.1, Horizontal End Suction Centrifugal Pumps for Chemical Process.
      f. ASTM C581, Practice for Determining Chemical Resistance of Thermosetting Resins used in Glass Fiber Reinforced Structures Intended for Liquid Service.
      g. ASTM C582, Specification for Contact-Molded Reinforced Thermosetting Plastic Laminates for Corrosion Resistant Equipment.
      h. ASTM D638, Test Method for Tensile Properties of Plastics.
      i. ASTM D695, Test Method for Compressive Properties of Rigid Plastics.
      j. ASTM D746, Test Method for Brittleness Temperature of Plastics and Elastomers by Impact.
      k. ASTM D790, Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
      l. ASTM D883, Terminology Relating to Plastics.
      m. ASTM D1248, Specification for Polyethylene Plastics Molding and Extrusion Materials.
      n. ASTM D1505, Test Method for Density of Plastics by the Density-Gradient Technique.
      o. ASTM D1693, Test Method for Environmental Stress-Cracking of Ethylene Plastics.
      p. ASTM D2310, Classification for Machine Made Fiberglass Pipe.
      q. ASTM D2563, Practice for Classifying Visual Defects in Glass-Reinforced Plastic Laminate Parts.
      r. ASTM D2583, Test Method for Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor.
      s. ASTM D2862, Test Method for Particle Size Distribution of Granular Activated Carbon.
      t. ASTM D2996, Specification for Filament-Wound, Fiberglass Pipe.

u. ASTM D3212, Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.
v. ASTM D3299, Specification for Filament-Wound Glass-Fiber-Reinforced Polyester Chemical Resistant Tanks.
w. ASTM D3350, Specification for Polyethylene Plastics Pipe and Fittings Materials.
x. ASTM D3467, Test Method for Carbon Tetrachloride Activity of Activated Carbon.
y. ASTM D3802, Test Method for Ball-Pan Hardness of Activated Carbon.
z. ASTM D4097, Specification for Contact-Molded Glass-Fiber-Reinforced Thermoset Resin Corrosion-Resistant Tanks.
aa. ASTM E679, Practice for Determination of Odor and Taste Thresholds by a Forced-Choice Ascending Concentration Series Method of Limits.
ab. ASTM F477, Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
ac. NBS Voluntary Product Standard PS15-69 Custom Contact Molded Reinforced-Polyester Chemical-Resistant Process Equipment.
ad. Society of the Plastics Industry (SPI) Standards of Recommended Practices for Shipping and Installation of Fiberglass Reinforced Plastic Pipe, Duct and Tanks.

2. Test results shall be submitted for review and approved by ENGINEER prior to manufacturer of fiberglass reinforced plastic items.

K. Prior to conducting any Odor Control System testing, demonstrate that all meters and test equipment have been calibrated, charged and are in good operating condition one working day before the test date. Shall also verify there is sufficient test gas to conduct testing for specified durations at specified concentrations.

L. Provide certifications that all stainless-steel accessories including hangers and supports for FRP and HDPE ductwork are Type 316 stainless steel.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
1. Submit for review to ENGINEER, sufficient literature, detailed specifications, and drawings to show dimensions, make, style, speed, size, type, horsepower, service factors, efficiency, materials used, design features, internal construction, weights, and any other information required by ENGINEER for review of all odor control equipment. No odor control equipment will be accepted, and installation will not be allowed until such review has been completed.

2. Additional requirements for information to be included with Shop Drawings are specified below:
    a. Shop Drawings for packaged biofilter odor control system shall include as a minimum the following:
        1) Dimensions of proposed biofilter and all associated fans, ductwork, piping, internal and external fittings, pipe and duct connections and appurtenances.
        2) Service Conditions: Chemical environment and temperature.
        3) Statement that fabrication shall be in accordance with these Specifications.
        4) Total operating weight of all equipment and biofilter media.
        5) Description of fabrication.
        6) Complete, detailed instructions on the installation of the scrubbers, which reference specifically the methods for these installations.
        7) Irrigation header piping, support details and nozzle pattern.
        8) Irrigation sprinkler data, material, pressure drop, coverage, flow rate, dispersion angle.
    b. Submittal for the exhaust fans shall include as a minimum the following:
        1) Manufacturer's certified rating data.
        2) Certified Shop Drawings showing all important details of construction, dimensions, and anchor bolt locations.
        3) Descriptive literature, bulletins, and catalogs of the equipment.
        4) The total weight of the equipment.
        5) A complete bill of materials.
        6) A list of the manufacturer's recommended spare parts with manufacturer's current price for each item. Include gaskets, packing, etc. on list.
        7) Complete data on motors, motor starters, manufacturer’s nameplate data and controls.
        8) Data on noise in accordance with AMCA #300.
        9) Description of surface preparation and shop primer and shop finish coating as specified in this Section.
        10) Inlet and outlet connection bolt hole patterns.
        11) Vibration eliminator data.
        12) Results of factory dynamic balance of fan and field check of dynamic balance of fan.
        13) Inlet vane damper.
        14) Motor control schematic wiring diagrams.

B. Ductwork Shop Drawings: Submit for approval the following:
    1. 1/4-inch scale duct layouts.
    2. Dimensions.
    3. Details of construction.
    4. Details of installation.
    5. Manufacturer's literature, illustrations, specifications, and engineering data.

6. Registers, grilles, and diffusers.
7. Fire Dampers (UL listed):
   a. Closing mechanisms.
   b. Fusible link operating temperature.
   c. Installation details.
   d. Access Doors.
8. Flexible connections.
9. Other technical data related to the specified material and equipment as requested by ENGINEER.
10. Duct sealants.
11. Deviations from Contract Documents
12. Manufacturer's specifications for FRP resins and reinforcing material used.
13. Manufacturer's specifications for fire-retardant epoxy FRP ductwork coating and reinforcing material used.
14. Specification of FRP ductwork laminate construction including schedule of duct sizes indicating weight per foot, wall thickness and all other data required for indicating conformance to FRP round duct schedule. Submit procedures for hand lay-up of duct joints.
15. Submit FRP rectangular duct schedule with sizes, thickness, vacuum pressure, weight per foot pressure, spans, joint type and flange data.
16. Submit HDPE duct schedule indicating size, wall thickness, weight per foot, joint type and ring stiffness constant.

C. Test Reports: Submit the following test reports for approval where required.
   1. UL Label, Fire Dampers.
   2. Volume Damper leakage tests from an AMCA approved testing laboratory.

D. Submit a letter from the resin manufacturer stating that the proposed resins in the fabrication of the FRP ductwork will provide satisfactory performance under the specified service conditions or a corrosion resistance chart indicating same.

E. Manufacturer's certified literature indicating compliance with proposed pressure and vacuum classification and wheel loading classification indicated below.

F. Tabulation in checklist forms to indicate compliance with ASTM D 2563 Table I, Level II visual acceptance levels.

G. Other calculations, dimensions or materials related to the specified product as requested by ENGINEER.

H. System Tests: Submit written performance test procedures for the following tests.
   1. Factory hydrostatic tests for scrubbers and chemical storage tanks.
   2. Odor Control System Field Tests.
   3. Performance tests of the multi-stage packaged chemical scrubbers and the carbon adsorbers.

4. Performance test of the overall Odor Control System.

I. Shop Test Results:
   1. Submit results of scrubber and chemical tanks hydrostatic tests.
   2. Submit results of routine factory motor tests.
   3. Submit results of material tests.

J. Field Test Results:
   1. Submit a written report providing the results of the field tests required.

K. Manufacturer's Reports:
   1. Submit a written report of the results of each visit by a manufacturer's serviceman, including purpose and time of visit, tasks performed, and results obtained.

L. Operation and Maintenance Manuals:
   1. Submit complete installation, operation, and maintenance manuals, including, test reports, maintenance data and schedules, description of operation and spare parts information.
   2. Furnish Operation and Maintenance Manuals in conformance with the requirements of Section 01781, Operation and Maintenance Data.

M. Lubricant Specification: Furnish a lubricant specification for the type and grade necessary to meet the requirements of the equipment.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Deliver materials to the site to ensure uninterrupted progress of the Work. Deliver anchor bolts and anchorage devices which are to be embedded in cast-in-place concrete in ample time to prevent delay of the Work.
   1. Responsibility belongs to CONTRACTOR for safe transportation, including all freight costs for delivery to the job site, procuring any necessary permits, handling, and open-air storage of the scrubber, fan, pumps, chemical storage tanks and other materials purchased as specified in this Section.
   2. Suction and discharge ports shall be protected against entry of foreign objects.
   3. Store equipment and materials so as to keep free from moisture, damage, and deterioration.

B. All boxes, crates and packages shall be inspected immediately by CONTRACTOR upon delivery to the site. Notify ENGINEER if any loss or damage exists to equipment or components. Replace loss and repair damage to new condition in accordance with manufacturer's instructions.

C. Store materials to permit easy access for inspection and identification. Keep all materials off ground, using pallets, platforms or other supports. Protect steel members and packaged materials from corrosion and deterioration.

1.5 EQUIPMENT INSPECTIONS

A. Inform OWNER and ENGINEER, four weeks prior to when specific equipment (e.g., scrubber, pumps, fan, etc.) goes into production, so that OWNER and ENGINEER, at their option, may visit premises prior to shipment of any equipment for approval of various items of major equipment. Manufacturer of major equipment shall not ship any equipment until ENGINEER has inspected and approved equipment, or manufacturer receives written permission from ENGINEER to ship equipment.

B. Factory inspection by ENGINEER shall not be construed to relieve CONTRACTOR of responsibility for accuracy of the fabrication and assembly, or the quality of workmanship.

C. Retain, label and submit cut-out samples of all FRP vessels to the ENGINEER for assessment of properties and laminate construction.

D. A thorough inspection of each piece of equipment will be conducted upon arrival at construction site to inspect for damage incurred in transit. Any damage shall be immediately repaired by respective equipment fabricator's personnel only, not a sales representative.

1.6 GENERAL REQUIREMENTS

A. The Drawings show general arrangement and extent of Work to be done, but the exact location and arrangement of all parts shall be determined as the Work progresses, to conform in the best possible manner with its surroundings. The exact location of all parts of the Work must be governed by the general building plans and the actual building conditions. Piping, equipment, ducts, etc. found to interfere with the construction of the building, plumbing apparatus and piping, electrical wiring or other obstructions, etc. shall be located to clear such obstructions. Connections shown to the various units are intended as an indication only. The actual connections shall be made and to best suit each particular case, provide for expansion, circulation and minimize the amount of space required.

B. Drawings do not show all offsets, fittings, accessories and details, which may be required. Examine all the Contract Documents for conditions, which may affect the installation of his Work, and shall arrange his Work accordingly. Provide all required items to complete the systems to the extent required by the Contract Documents.

C. If piping or ductwork can be run to better advantage, CONTRACTOR, before proceeding with the Work, shall prepare and submit complete Shop Drawings showing all details of the proposed rearrangement for written approval by the ENGINEER.

1.7 ODOR CONTROL SYSTEM PERFORMANCE REQUIREMENTS

A. The odor control system shall meet the following performance requirements:

Parameter	Units	Value
Nominal Air Flow	CFM	3,500
Nominal Inlet Air Temperature	Deg F	50 – 120
Foul Air Contaminants	--	Hydrogen Sulfide, Wastewater Odors
Estimated Foul Air Hydrogen Sulfide Concentration	ppm	10 – 200
Odor Control System Area	ft^2	As Indicated on the Drawings
Nominal Media Depth	ft	6
Hydrogen Sulfide Removal Efficiency	%	99%

1.8 EQUIPMENT DEFECTS

A. Equipment, which have mechanical defects and that do not meet vibration requirements, will be rejected and shall be replaced at CONTRACTOR'S full expense for furnishing, installing, removal, and replacement.

B. Mechanical defects shall include excessive vibration, improper balancing of rotating parts, improper tolerances, binding, excessive bearing heating, defective materials, improper fitting of parts, and any other defect which will in time damage the equipment or impair its operation.

C. Requirements shall be met concerning minimum and maximum dimensions and the specifications for materials. If it is found upon delivery that materials do not agree with the requirements of the Specifications as to size, type, quality, or metallurgy, they will be rejected as unfit for use in this Work.

PART 2 -PRODUCTS

2.1 GENERAL

A. Provide a complete biofilter odor control system specified to treat in a single pass the odorous foul air from the lift station wet well. The systems shall be designed for continuous and automatic operation and also be capable of manual operation.

2.2 PRODUCT AND MANUFACTURER

A. As manufactured by one of the following:
   1. Bohn Biofilter
   2. Approved equal.

2.3 FABRICATION SPECIFICATIONS

A. All fiberglass reinforced plastic (FRP) equipment specified in this Section shall be custom contact molded manufactured in accordance with NBS PS 15-69, ASTM D 4097 for contact molding and ASTM D 3299 for filament winding. Any visual defects shall not exceed ASTM D-2563 Table 1, Visual Acceptance Level II. Any material of construction other than FRP with premium grade vinyl ester resin will not be allowed.

B. Resin used in fabrication shall be a premium vinyl ester type such as Hetron 922 by Ashland Chemicals, Derakane 411 by Dow Chemical or equal. The resin shall be reinforced with an inner veil of a suitable synthetic organic fiber such as Nexus 1012.

C. Reinforcement: Glass fiber reinforcement used shall be commercial grade corrosion resistance borosilicate glass.
   1. All non-molded surfaces shall be coated with resin incorporating paraffin to facilitate a full cure of the surface. All cut edges, bolt holes, secondary bonds shall be sealed with a resin coat prior to the final paraffinated resin coat.
   2. Corrosion Liner: The inner surface of all laminates shall be resin rich and reinforced with two coats of NEXUS 1012 with a minimum thickness of 20 mils total. The interior corrosion layer shall consist of two layers of 1-1/2 oz. per square foot chopped strand mat. The total corrosion liner thickness shall be a minimum of 100 mils.
   3. Structural Laminate: Structural laminates shall consist of alternating layers of 1-1/2 oz. per square foot mat or chopped glass and 24 oz. per square yard woven roving applied to reach a designed thickness. The exterior shall be surface coated with white gel coat containing ultra violet light inhibitors.
   4. All glass fiber reinforcement shall be Type "C" (chemical grade) or Type "E" (electrical grade).
   5. Surfacing veil shall be 10 mil Nexus 1012 or equal.
   6. Mat shall be Type "E" (electrical grade) glass, 1-1/2 oz. per square foot with a nominal fiber length of 1.25 ± 0.25-inches, with a silane finish and styrene soluble binder.
   7. Continuous glass roving, used in chopper gun spray-up applications shall be Type "E" grade with chrome or silane coupling agent.
   8. Woven roving used for reinforcement shall be 24 oz. per square yard Type "E" glass and have a 5 by 4 plain weave.

D. Miscellaneous:
   1. All fasteners and metal attachments, including nuts, bolts, washers, handles, anchors, brackets, etc. shall be Type 316L stainless steel, unless otherwise specified.
   2. Gaskets: All gaskets for the Odor Control System equipment ductwork and all connections shall be EPDM.
   3. Drain lines shall allow complete drainage of the vessel and duct contents.

2.4 EXHAUST FANS

A. General:
   1. Furnish and install Type 316L stainless steel exhaust fans with entire air stream surface graphite impregnated, complete with motor, drive, belt and belt guard mounted on a rigid base plate and support base.

B. Type: Base mounted Type 316L stainless steel exhaust centrifugal fans:
   1. Single width, single inlet, backward curved Type 316 stainless steel impeller, Class IV centrifugal fan with fixed discharge. Fans shall be tested and rated in accordance with ASHRAE 51-75 and AMCA 210-74 test code, and be licensed to bear the AMCA seal and be guaranteed by manufacturer to deliver rated performance.
   2. Housing: Fan housing shall be designed so that air leakage through the joints and seals is negated. All bolted pieces shall be EPDM gasketed. The housing shall be Type 316L stainless steel.
   3. Fan Shaft: Shaft shall be of Type 316L stainless steel construction designed to operate below the first critical speed. Shaft and impeller shall be statically and dynamically balanced. Provide mechanical or Teflon seal between shaft and housing.
   4. Inlet Cone: Type 304 stainless steel spinning. Fabricated cones not acceptable.
   5. Shaft Seal: Viton double lip type, complete with lubrication fitting for lubrication of annular space required between seal elements.
   6. Bolts, nuts, and hardware on wheel and hub shall be Type 316L stainless steel.
   7. Bearings: Antifriction, self-aligning, grease-lubricated ball or pillow block type; supported on fabricated steel base with additional bearing support blocks. Minimum AFBMA B-10 life rating of 100,000 hours; bearings to have extended lubrication lines.
   8. Support Bases: Heavy structural steel subbase frames with minimum 6-inch channel, coated in accordance with Section 09900, Painting. Provide slots for anchoring to fan equipment pad. Provide Type 316L stainless steel hardware and anchors.
   9. Inlet vane dampers shall be provided by fan manufacturer and to be designed for minimum pressure loss. Motorized damper shall be Type 316L stainless steel.

10. Fan inlets to be provided with a flanged flexible connector manufactured by Holz, or equal.
11. Vibration Sensor: Fans shall be provided with Vitec, Inc., Model 438 or equal, vibration switches mounted on bearing pedestal/base. Control voltage to be 120 volts. Switches shall be adjustable trip points and provided in cast aluminum NEMA 4 enclosures. Switch shall be capable of providing an output signal, which may be used for alarm, indication, or fan shutdown.
12. Fan noise shall be in accordance with SMACA #300 and OSHA requirements. Acoustic attenuation shall be provided as necessary to meet sound requirements. Fan noise shall not exceed 80 dBA at five feet.

C. Drives and Motors:
1. Motors: Horizontal, TEFC with a 1.15 service factor, rated for 3,500 RPM, outdoor service with ambient temperatures that range from 0°C to 50°C, equipped with H insulation. Motors shall also be in accordance with Section 11000, Electric Motors, and with the characteristics indicated in Fan Schedule, below.
2. Motor shall meet the requirements of the fan.
3. Belt Guards shall be epoxy coated steel. Paint in accordance with Article 2.11, below.
4. Support Bases: Heavy structural steel frame common with fan.

D. Fans shall be designed to meet the following schedule:

Equipment ID:	Air Flow Rate, cfm	S.P. up to Scrubber inlet, (in WC)	Total System Pressure Drop (in WC)	Motor Voltage (V, Ph, Hz)	Motor HP
BLWR-1200	3,500	2	14	480, 60, 3	7.5

E. As manufactured by one of the following:
1. New York Blower Co.
2. Buffalo Forge.
3. Hartzell.
4. GE Industrial Motors.

2.5 BIOFILTER MEDIA AND ACCESSORIES

A. General:
1. Furnish and install amended soil media specifically designed to degrade odorous constituents from municipal wastewater lift stations. Media shall consist of a blend of sand, soil that is delivered to the jobsite moist, blended and ready-to-place.

2. Furnish and install 40-mil polyethylene containment liner equipped with tape-on boots, felt geomembrane and all hardware and accessories for attachment to the concrete tank.
3. Furnish and install raised flooring system that consists of high-density polyethylene (HDPE). All connections and perforations shall be prefabricated and designed to be readily installed.

B. Grease Filter:
1. Furnish and install a grease filter designed to remove airstream particulates.

C. Automated Irrigation System:
1. Furnish and install an automated sprinkler system that provides complete coverage of the biofilter. Sprinkler system shall be independently controlled by an automated timer and include all ancillary components up to the non-potable water connection. Sprinkler pipe shall be Sch 80 PVC with a minimum size of 1-inch diameter.

2.6 INSTRUMENTATION AND SYSTEMS CONTROLS

A. The control panel(s) shall be furnished in accordance with the requirements as shown on the Contract Drawings, and as specified in Division 17000, Sections 17051 – Computer Control System Process Control Descriptions, 17052 – Process Control System Primary Sensors and Field Instruments, 17053 – Process Control System Instrument Index, 17226 – Process Control System I O List, and 17260 – Control Panels. All panel enclosures shall conform to the requirements of specification 16050 – General Provisions.

C. Exhaust Fans Control Panel:
1. The control panel(s) shall be furnished in accordance with the requirements as shown on the Contract Drawings, and as specified in Division 17000, Sections 17051 – Computer Control System Process Control Descriptions, 17052 – Process Control System Primary Sensors and Field Instruments, 17053 – Process Control System Instrument Index, 17226 – Process Control System I O List, and 17260 – Control Panels. All panel enclosures shall conform to the requirements of specification 16050 – General Provisions.
2. The Panels shall be factory tested to full operation with all other components prior to shipment
3. The panel shall have the following components or capabilities:
   a. Main Disconnect switch, with lockable handle on enclosure door.
   b. Combination starters with overloads for exhaust fans.
   c. Fan control switch (HAND /OFF/AUTOMATIC) and push-to-test pilot lamp for each exhaust fan.
   d. Control devices such as relays, control transformers, pushbuttons and indicating lights as required for fan motor controls.

e. Four N.O. auxiliary contact outputs for exhaust fans ON/OFF status to remote HVAC equipment.
f. Auxiliary contacts and termination blocks for output signals to the CCS.

4. Product and Manufacturer. Provide one of the following.
   a. Utilize a manufacturer listed in Section 17260 – Control Panels
   b. Or equal

2.9 FIBERGLASS REINFORCED PLASTIC (FRP) DUCTWORK AND ACCESSORIES

A. The fiberglass reinforced plastic duct system shall be specifically designed, constructed, and installed as shown on the Drawings for the following minimum conditions.
   1. Ambient Air Temperature: 20°F to 125°F.
   2. Corrosion resistance to hydrogen sulfide, chlorine, mercaptans and other gases commonly encountered in wastewater treatment plants.
   3. Vacuum Service: Minimum 10-inch water gage.
   4. Pressure Service: 20-inch water gage.

B. Fiberglass reinforced plastic (FRP) ductwork shall be of filament wound or hand lay-up construction. FRP ductwork shall be of flame retardant material inside and outside in accordance with NFPA-91. All ducts shall be installed in accordance with manufacturer's recommendations.

C. FRP Duct Construction:
   1. Duct shall meet the applicable requirements of ASTM D 2310, Type 1, Grade 1 or 2, with Class "E" liner, 20 mils minimum thickness, and be manufactured in accordance with ASTM D 2996. Flanges and bolt drilling circles and diameters shall conform to NBS PS 15-69, except that flanges shall be a minimum of 0.75-inches thick. Ductwork shall be fabricated of vinylester resin as specified below. All interior and exterior surfaces of ducts, dampers and FRP accessories shall be coated with a minimum 90 percent resin, five percent antimony trioxide and nexus veil reinforcement. Exterior surfaces shall have a factory applied paraffinated pigmented gel coat finish with ultra-violet inhibitors.
   2. Ductwork shall be in accordance with SMACNA Thermoset FRP Duct Construction Manual.

D. Laminates shall consist of a 20 mil chemical resistant liner with a synthetic surfacing veil embedded in a resin rich surface. The corrosion barrier shall be a minimum of 100 mils and include no less than two layers of 1-1/2 ounce mat with 25 percent glass and 75 percent resin content. The structural layer shall be of sufficient thickness to meet the minimum thickness requirements specified. The exterior surface layer shall be resin rich apertured nexus veil not less than 20 mils thick. Outside finish shall have a parrafinated pigmented gel coat finish with an

ultra violet inhibitor. Provide standard and custom color chart for color selection. The composition specified for the inner surface and interior layer is intended to achieve optimum chemical resistance.

E. Resins used in the laminate shall be premium corrosion resistant and fire retardant brominated biphenol-A vinylester resins such as Dow Chemical Company, Derakane 510A with five percent antimony trioxide, Reichhold Dion 9300 FR with five percent Antimony Trioxide or Ashland Chemical Company, Hetron FR 992 with three percent antimony trioxide or equal. The synthetic surfacing veil shall be Veil-Nexus 1012 (apertured) as manufactured by Burlington Industries.

F. All cut edges shall be sealed with a resin coating of the same resin as used in the fabrication. The resin shall contain paraffin.

G. Product and Manufacturer: Provide one of the following:
1. Ceilcote Company, Inc.
2. Ershigs Incorporated.
3. Sponstrand.
4. Daniel Mechanical.
5. FanAir.
6. RK Fabrication.
7. Or equal.

H. All FRP ductwork installed within the interior of any building shall be additionally protected with a two-component catalytic epoxy intumescent fire-retardant coating.
1. Reference: United States Military Specification, MIL-C-46081A.
2. Surface Preparation: All mold release agents and other foreign matter shall be completely removed. All glossy surfaces shall be brush-blasted or sanded and cleaned.
3. Product and Manufacturer: Provide one of the following:
   a. Flame Control Coatings, Incorporated, Flame Control No. 46081 Thermal Insulating (Intumescent) Epoxy Paint.
   b. Or equal.
4. Laminate must be fully cured before application of fire-retardant coating.
5. Apply first coating minimum eight to ten mil (wet) over duct.
6. Immediately apply one layer of C-Veil onto wet coating. Brush or roll C-Veil to remove any creases and to completely wet C-Veil.
7. Apply second layer of intumescent coating at eight to ten mil (wet) minimum thickness. Dry thickness of two coats plus C-Veil shall be not less than 10 mils.
8. Apply additional coats as required to ensure that C-Veil is completely immersed in the epoxy coating and completely wetted and that the total dry thickness will be greater than ten mils. There shall be NO exposed or dry C-Veil.

9. The flame spread rating of the fire-retardant coating shall not exceed 25 and the smoke developed rating shall not exceed 50. The manufacturer shall submit test data indicating that the fire retardant system does not exceed listed ratings and has been tested by Factory Mutual Research Corporation.
10. Provide standard and custom color chart for color selection.

I. Fittings and Joints: All fittings such as elbows, laterals, tees, and reducers shall be of the same resin as and equal or superior in strength to the adjacent duct section and shall have the same internal diameter as the adjacent duct. Round duct joints shall be butt wrapped or bell and spigot joints as shown on the Drawings or required. Bell and spigot joints shall be sealed with a standard butt joint overlay as per PS 15-69. All interior surfaces of joint to be coated with a paraffinated resin-rich gel coat.

J. Total width of overlay for butt-wrap joints shall be not less than 6-inches for diameters from 8-inches up to and including 30-inches, 36-inch and larger shall be not less than 10-inches.

K. Standard Elbows:
1. Standard elbow centerline radius shall be equal to a minimum of 1-1/2 times the diameter.
2. Standard elbows up to 24-inch diameter shall be smooth radius molded elbows. Standard elbows 30-inch diameter and greater may be mitered sections as specified below.
3. 0 to 44 degree elbows shall contain one mitered joint and two sections. 45 to 80 degree elbows shall have a minimum of two mitered joints and three sections. Elbows greater than 80 degrees shall have a minimum of four mitered joints and five sections.

L. Maximum allowable deflection for any size ductwork shall be 1/2-inch between supports and for any side of duct under worse case operating conditions. Ductwork supports shown on the Drawings are a minimum number required. Additional supports shall be provided as required to meet the specifications. Additional supports shall be the same as adjacent support details.

M. Tolerances:
1. Out-of-roundness of duct shall be limited to ±1/8-inch or ± one percent of duct inside diameter; whichever is greater for duct sizes 8-inch diameter and greater.
2. Length of all flange pipe sections shall not vary more than ±1/8-inch at 70°F.
3. All unflanged duct shall be square on the ends in relation to the pipe axis and ±1/8-inch up to and including 24-inch diameter and ±3/16-inch for all diameters greater than 24-inch.

4. Fittings:
   a. The tolerance on angles of all fittings shall be ± one degree, up to and including 24-inch diameter and ±1/2 degree for 30-inch diameter and above.
5. Flanges:
   a. Flange faces shall be perpendicular to the axis of the duct within 1/2 degree.
   b. Flange faces shall be flat to within ± 1/32-inch, up to and including 18-inch diameter and flat within ± 1/16-inch for 20-inch diameter and larger.
   c. Provide custom filler pieces as required to mate flanges squarely.

N. Calculations for wall thickness determination shall be based on the structural fiberglass reinforced wall only. FRP ductwork shall be designed using a safety factor of ten to one for pressure and five to one for vacuum service. Ductwork shall be designed by manufacturer to resist all system forces and meet specified deflection requirements, but in no case shall FRP be less than the thickness listed in the table below.

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MINIMUM FRP ROUND DUCT DIMENSION AND PERFORMANCE SCHEDULE							
ID (in.)	Wall Thickness (min.) (in.)	Minimum Allowable Vacuum[1] (in. of water)	Minimum Allowable Pressure[1] (in. of) water)	Flange Thickness (in.)	Bolt Circle Diameter (in.)	Bolt Size and No. of Bolt Holes	Maximum Allowable Span[2] (ft)
2	0.125	405	705	3/4	4-3/4	5/16 /4	9
3	0.125	405	500	3/4	6	5/16 /4	11
4	0.125	210	410	3/4	7-1/2	5/16 /8	12
6	0.125	64	350	3/4	9-1/2	5/16 /8	15
8	0.187	182	693	3/4	11-3/4	5/16 /8	17
10	0.187	94	693	3/4	14-1/4	5/16 /12	19
12	0.187	55	693	3/4	17	5/16 /12	20
14	0.250	91	693	3/4	18-3/4	1 /12	20
16	0.250	61	693	3/4	21-1/4	1 /16	20
18	0.250	44	693	3/4	22-3/4	1-1/8 /16	20
20	0.250	33	693	3/4	25	1-1/8 /20	20
24	0.250	18	693	3/4	28-1/2	1-1/4 /20	20
30	0.312	20	693	3/4	36	1-1/4 /28	20
36	0.375	23	693	3/4	42-3/4	1-1/2 /32	20
42	0.375	15	693	3/4	49-1/2	1-1/2 /36	20
48	0.437	15	693	3/4	56	1-1/2 /44	20
54	0.437	15	693	3/4	62-3/4	1-3/4 /44	20
60	0.437	15	693	3/4	69-1/4	1-3/4 /52	20
96	0.750	15	693	1	(3)	(3)	20

NOTES:

1. These ratings were suitable for use up to 180°F (82.2°C) in pressure service and ambient atmospheric temperatures on vacuum service. For ratings at high temperatures, consult manufacturer.
2. Based on 1/4-inch span deflection on air conveying systems at 180°F maximum. Also, based on duct systems not subjected to more severe service conditions such as additional weight caused by liquid or solids build-up in duct system, effects of wind loading on outdoor installations, or possible failure of intermediate duct hangers. Provide as a minimum, the number of duct supports as shown on the Drawings. Support continuous at all non-flanged pipe end connections.
3. Submit for approval.

O. All connections to expansion joints, butterfly dampers, tanks, or other equipment shall be flanged. Duct flanges shall conform to the FRP Duct Schedule above. Gaskets shall be EPDM. Bolts, nuts and washers shall be Type 316 stainless steel. Flanges shall be hand laid up to PS 15-69 thickness, except that minimum thickness shall be 3/4-inch. The flange shall be hand laid-up anchored to a waxed table to achieve the flatness tolerance outlined in Paragraph 2.4.M.5., above. The face shall be textured for use with full-face gaskets, as specified above, 1/8-inch minimum thickness. Pipe flange drilling shall be NBS PS 16-69. All FRP duct and pipe flange boltholes shall be back spot faced for a washer seat. All flange bolts shall be torqued to values as recommended by manufacturer.

P. Hangers:
   1. All ductwork shall be supported from trapeze type hangers. Hanger rods shall be minimum 3/8-inch for all ducts with half perimeter up to 72-inches, and 1/2-inch diameter for all ducts with half perimeter larger than 72-inches. A pair of rods shall be provided at each duct support point.
   2. All hangers, rods, supports, bolts, nuts, washers, inserts, and appurtenances located in corrosive areas shall be Type 316 stainless steel.
   3. Hanger Construction and installation shall conform to SMACNA Standards, except as specified. No sheet metal duct hangers or straps will be allowed.
   4. Supports shall be provided at each fitting.

Q. There shall be not less than a 1/4-inch buildup of FRP over the duct at each support. Each support shall be furnished with a 1/8-inch thick teflon sheet to shield the duct from the support. The teflon sheet shall extend beyond the support plate at least 1/2-inch on all sides.

R. Furnish flexible connectors for every 100 linear feet of run and wherever ductwork crosses an expansion joint as a minimum and as shown on the Drawings with anchors and guides. Flexible connections shall be W-design units constructed of EPDM. Expansion service flexible connections shall be designed to allow 1-inch of contraction and 3.8-inches of expansion. Working length or flange-to-flange length shall be a minimum of 12-inches. Ends shall be flanged, with flanges conforming to NBS PS 15-69. Corners on rectangular expansion joints shall be molded and free of patches or splices. The flexible connections shall be suitable for outdoor service and temperature ranges from -65°F up to 250°F, and pressure to 20 psig. Specially fabricated split 3/8-inch thick Type 316L stainless steel retaining back-up bars shall be supplied to prevent damage to the EPDM rubber flanges when Type 316L stainless steel bolts are tightened.
   1. Product and Manufacturer: Provide one of the following:
      a. Holz Rubber Company.
      b. Pathway Bellows Incorporated.
      c. Mercer Rubber Company.
      d. Or equal.

S. Round Fiberglass Reinforced Plastic Dampers:
   1. Furnish and install where shown on the Drawings manually operated round butterfly dampers.
   2. Rating Conditions:
      a. Velocity Through Damper: 5,000 fpm.
      b. Pressure Rating: 30-inches water column.
      c. Maximum Allowable Leakage: Three cfm per square foot at 10-inch w.g. pressure.
   3. Materials:
      a. Bearings: Teflon.
      b. Blade: FRP, reinforced.

c. Frame: FRP channel.
d. Axles: Type 316L stainless steel rods, full length of damper size as shown on the Drawings.
e. Finish: FRP.
f. Handle: Type 316L stainless steel.
g. Pins: Type 316L stainless steel.
h. Bushings: Teflon.
i. Hardware: Hastelloy-C.
j. Angles: FRP.
k. Flanged ends with bolt holes drilled to match connecting ductwork.
l. Blade Stops: FRP angles with full circumference EPDM seal.

4. Dimensions: As required.
5. Leakage test and performance data from an AMCA approved testing laboratory shall be submitted.
6. Provide the dampers for manual operation with hand quadrant and shaft seals.
7. Product and Manufacturer: Provide one of the following:
   a. Swartwout, Phillips Industries, Model 914.
   b. Or equal.

T. FRP Transition Pieces:
1. Provide transition pieces as shown on Drawings and herein specified.
2. Construction:
   a. 1/4-inch minimum thickness FRP sheets and thickness not to be less than thickness of adjacent FRP ducting.
   b. All exposed hardware shall be Hastelloy-C screws, nuts, bolts and washers, as required.
   c. Flanges shall be designed as required to connect to fan or ductwork.
3. Pressure Classification: Manufacturer shall design transition pieces so that they shall be free from buckling, pulsing, warp age, sagging and to the following pressure ratings:
   a. Vacuum Service: 10-inches water gage, minimum.
   b. Pressure Service: 20-inches water gage, minimum.

U. Install round pipe sleeves and mechanical seals for all round duct wall and floor penetrations as herein specified:
1. Non-metallic, non-corrosive, high-density polyethylene construction.
2. Integral formed water stop and anchor plate.
3. Sleeve and mechanical seal shall be manufactured by Thunderline Link-Seal or equal.

V. Install end caps on the end of each duct branch and provide a bolted duct access door at the end of each branch prior to the duct turning to connect to the HDPE underground ducting. Access door dimensions shall be 6-inches less than the duct diameter.

W. Tools, Spare Parts and Maintenance Materials:
   1. The duct system shall be furnished with the following:
      a. Two sets of special tools required to maintain and repair the system.
      b. All materials in kit form to make or repair joints. Kits shall be in a number sufficient to repair ten percent of the joints.
      c. Names and addresses of all manufacturers of: Fiberglass reinforcements, resins, hardeners and components used to repair and maintain FRP duct system.
   2. Spare parts shall be packed in sturdy containers with clear indelible identification markings and shall be stored in a dry, warm location, until transferred to the OWNER at the conclusion of the Project.
   3. Refer to paragraph 2.13 of this Section.

2.10 HIGH DENSITY POLYETHYLENE PIPE AND ACCESSORIES

A. High density polyethylene pipe (HDPE) shall be used for underground odor control ductwork only. In this Section and on the Drawings HDPE pipe, HDPE duct and foul air duct shall be used interchangeably.

B. The pipe shall be manufactured by the continuous winding of a special profile onto suitably sized mandrels with bell and spigot ends. It shall be produced to constant internal diameters. The pipe wall profile shall be in accordance with the manufacturer's recommendation. If solid wall pipe is used it shall be manufactured by conventional extrusion and utilize field butt fused joints. The solid wall pipe proposed shall provide for a minimum inside diameter as shown on the Drawings. Wall thickness shall be based on depth of burial, and assuming an H-20 loading under construction conditions. Depth of duct burial as shown on the Drawings.

C. Pipe wall construction shall present a smooth wall in the air stream, but may include exterior ribs that help brace the pipe against diametrical deformity. The Hazen-Williams friction factor shall be no less than a value of 155.

D. All HDPE pipe and fitting ends shall have bell and spigot end construction, except at transitions to dampers, appurtenances and to FRP duct. Fabricated flange connections shall be provided at connections to dampers, appurtenances and FRP duct. Field installed joining shall be accomplished by mechanical joints with centering ring EPDM gaskets or flanged connections with EPDM gaskets, as required.

E. The manufacturing of fittings shall be accomplished by cutting the required pieces from stock pipe and joining the pieces by thermal welding. Weld location for fittings shall be at the manufacturer's option.

F. The pipe and fittings shall be made of high density, high molecular weight polyethylene pipe material meeting the requirements of Type III, Class C, Category

5, Grade P34, as defined in ASTM D 1248 Standard Specification for Polyethylene Plastics Molding and Extrusion Materials. Materials conforming to the requirements of cell classification PE 334433C or higher cell classification in accordance with ASTM D 3350 are also suitable for making pipe products under these Specifications. Clean rework material generated by the manufacturer's own production may be used so long as the pipe or fittings produced meet all the requirements of this Section.

G. Centering ring gaskets shall be provided and conform to the requirements of ASTM F 477 and be molded into a circular form or extruded to the proper section and then spliced into circular form and shall be made of a properly cured high grade elastomeric compound. The basic polymer shall be EPDM and shall be suitable for constant exposure to wet hydrogen sulfide.

H. Lubricant used for installation of centering rings shall have no detrimental effect on the centering ring or on the pipe.

I. Material used for extrusion-welded pipe joints shall meet the requirements established for the basic pipe material as detailed above.

J. Pipe and fittings shall be homogenous throughout and free from visible cracks, holes, foreign inclusions or other injurious defects. The pipe shall be as uniform as commercially practical in color, opacity, density and other physical properties.

K. Fittings such as couplings, wyes, tees, adapters, etc. for use in laying HDPE pipe shall have laying length dimensions as recommended by the manufacturer, elbows shall be mitered as specified for FRP ductwork, herein. Field fabrication of any fittings shall not be permitted.

L. All connections, when joined in accordance with manufacturer's recommendations, shall show no sign of leakage when tested in accordance with ASTM D 3212, with the exception that the shear load transfer bars and supports shall be replaced with 6-inch wide support blocks that can be either flat or contoured to conform to the pipe's outer contour.

M. The manufacturer shall furnish a certificate of conformance, certified test results and copies of the test report in accordance with Division 1, General Requirements.

N. Each standard and random length of pipe in compliance with this standard shall be clearly marked with the following information:
   1. Pipe Size.
   2. Pipe Class.
   3. Production Code.
   4. Material Designation.

O. If the results of any tests do not conform to the requirements of this Section, the tests shall be conducted again. If upon retest, failure occurs, the quantity of product represented by the tests shall be rejected and replaced at no additional cost to the OWNER.

P. Product and Manufacturer: Provide one of the following:
1. Plexco/Spirolite.
2. Or equal.

2.11 SURFACE PREPARATION AND PAINTING

A. Pumps, motors, drives, frames, baseplates, appurtenances, etc., shall receive shop primer and shop finish coating conforming to the requirements of Section 09900, Painting. If any damage to the paint system occurs, the equipment shall be repainted as directed by the ENGINEER.

B. Surface preparation and painting shall conform to the requirements of Section 09900, Painting.

C. All gears, bearing surfaces, machined surfaces and other surfaces which are to remain unpainted shall receive a heavy application of grease or other rust-resistant coating. This coating shall be maintained during storage and until the equipment is placed into operation.

D. Certify, in writing, that the shop primer and shop finish coating system conforms to the requirements of Section 09900, Painting.

E. All FRP exterior surfaces of pipe duct and fittings shall be painted with an approved epoxy paint system conforming to the requirements of Section 09900, Painting.

F. Ductwork shall be factory painted in accordance with paint system specified below.

G. Provide a sample FRP panel not less than two square feet which shall be painted and allowed to dry for not less than 48 hours and then be checked for paint adhesion by the paint system manufacturer and submitted to the ENGINEER.

2.12 DUCT SUMP LIQUID LEVEL SENSORS

A. Furnish and install at each foul air duct condensate trap in a float type liquid level sensor with waterproof corrosion resistant cables, length as required. Provide conduit in accordance with Division 16, Electrical. Floats shall have chemical resistant polyethylene casing over epoxy filler with cable molded into end. The epoxy filler shall encase a normally open mercury switch rated at 20 amps at 120 volts. Cable clamps shall be polypropylene with Hastelloy-C trim. Furnish and install Hastelloy-C compression type cable grips where electrical cable passes

through duct wall. Upon a rise in liquid level the mercury switch shall "make", actuating a high level alarm light on the panel located above the sump access door. On a drop in the liquid level the mercury switch shall "break" turning off the high level alarm light in the panel.

2.13 TOOLS AND SPARE PARTS

A. Tools: Furnish two sets of all special tools that are required to assemble, disassemble, repair, and maintain the equipment. Special tools shall include any type of tool that has been specifically made for use on an item of equipment for assembly, disassembly, repair and maintenance. When special tools are provided they shall be marked or tagged, and a list of such tools shall be included with maintenance and operation instructions describing use of each marked tool.

B. Spare Parts: Additional requirements shall be included with individual items of equipment. Spare parts shall be packed in sturdy containers with clear indelible identification markings, referencing the equipment that they are intended for, and shall be stored in a dry, warm location until transferred to the OWNER at the conclusion of the project. Provide completed ordering information including manufacturer, part number, part name and equipment for each part to be used. Comply with the requirements of Section 01783, Spare Parts and Maintenance Materials.

C. Furnish and deliver the following spare parts for the fan:
   1. Three sets of spare belts.
   2. Three sets of bearings.
   3. Three replacement seals.
   4. One spare fan shaft.

D. Furnish solvents for cleaning dirt, grease and oil from surface of non-metallic parts.

E. Spare parts shall be packed in sturdy containers with clear indelible identification markings and shall be stored in a dry, warm location until transferred to the OWNER at the conclusion of the Project.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Furnish, install, and test the Odor Control System.

B. Equipment shall be installed as specified herein, as indicated on the Drawings, and in accordance with the manufacturer's recommendations and instructions. Equipment shall be installed in such manner that connecting piping will not impose any strain whatever on any equipment. Equipment shall be set upon grouted foundations, level or perpendicular, as the case may be, so that connecting flanges,

screwed connections, or flexible connections will meet without strain or distortion. Base leveling nuts shall be blocked out during grouting of foundations, the grout allowed to set for not less than three days, leveling nuts loosened and followed by grouting of block-outs, with non-shrink grout as specified in Section 03600, Grout.

C. Install the fans in accordance with the fan manufacturer's recommendations and instructions.

D. All equipment shall be installed with Type 316L stainless steel anchor bolts as specified in Section 05051, Anchor Bolts, Toggle Bolts and Concrete Inserts.

E. All equipment furnished under this Section shall be suitable for installation as shown on Drawings and specified herein. Field verify locations, sizes and elevations for all connections. Responsibility belong to CONTRACTOR for determining the necessary clearances and headroom required to move all equipment to its final location.

F. In every case where a drive motor is connected to a driven piece of equipment by a flexible coupling, the coupling halves shall be disconnected and alignment between motor and equipment checked and corrected. Machinery shall first be perfectly aligned and leveled by means of steel wedges and shims near anchor bolts. Anchor bolts shall be tightened against shims on wedges and equipment shall again be checked for level and alignment before placing grout.

G. Equipment bases shall not be grouted nor foundation bolts finally tightened until all piping connections are complete and in satisfactory alignment with no strain transmitted to the equipment.

H. Examine pads or supports to receive scrubber, fan, and pumps for:
   1. Proper anchor bolt locations.
   2. Unevenness, irregularities and incorrect dimensions.

I. Supervise installation in accordance with scrubber manufacturer's instructions and recommendations.

J. Provide flanged flexible connections at air inlet and discharge of scrubber exhaust fan.

K. All flexible connections with air handling equipment will be supported at both ends within 18-inches of joint.

L. Installation and testing of pumps shall be in complete accordance with manufacturer's instructions and recommendations and Division 11, Equipment.

M. All equipment shall be installed on concrete bases and secured with anchor bolts in accordance with the manufacturer's recommendations and as shown on the Drawings. Concrete bases shall be poured to an elevation to facilitate proper installation and access.

N. Provide 1-inch CPVC pipe on each pump and fan to convey leakage to nearest drain-age point.

O. Installation shall include furnishing and applying an initial supply of grease and oil, recommended by the respective manufacturers.

P. Support piping independent of pumps.

Q. Connect all piping, valves and accessories as detailed on the Drawings and approved Shop Drawings.

R. Install all conduit and wiring and complete all connections.

S. Provide certification by Registered Professional Engineer, licensed in the State of Arizona, that Odor Control Systems and scrubber have been installed in accordance with the Contract Documents.

T. The biofilter media and associated exhaust fan system shall be placed on a concrete foundation. Concrete work and grout are specified in Section 03300, Cast-In-Place Concrete and Section 03600, Grout.

3.2 DUCTWORK INSTALLATION

A. All ductwork shall conform accurately to the dimensions shown on the Drawings, the ducts shall be straight and smooth inside with joints neatly finished; ductwork shall be installed so as to preclude the possibility of vibration under all operating conditions.

B. Tape and seal all joints in accordance with SMACNA Standards.

C. Elbows shall have a minimum centerline radius of 1-1/2 times the width of the duct. Turning vanes shall be provided at all square elbows. Turning vanes shall be double wall and shall be quiet and free from vibration when the system is in operation.

D. Test holes shall be provided at each duct connection and at all air moving equipment. Test holes shall be factory installed with no exposed fibers.

E. Provide manual stainless steel splitter dampers and volume dampers where indicated on the Drawings and as required to facilitate accurate volume control. The duct of the damper shall be reinforced to prevent vibration.

F. Fire dampers shall be provided and installed where indicated on the Drawings and where required by U.L. and authorities having jurisdiction, and shall be approved by the Phoenix Building Code and in accordance with the requirements of the NFPA.

G. Provide access doors for all dampers for inspection and maintenance.

H. Install all ductwork and accessories to provide a system free from buckling, warping, breathing or vibration.

I. All expansion joints and ducts shall be suitably supported at each end by support guides within 12-inches of joint.

J. All ducts at flexible connections with fans shall be supported at free end within 12-inches of flexible connection.

K. Provisions shall be made for supporting all ductwork, dampers, and other ductwork accessories, where necessary.

L. Coordinate all air outlets for compatibility with ceiling system.

M. All low points in the Odor Control System ductwork shall be provided with 1-1/4-inch drains, unless otherwise noted. All drains shall be provided with a 10-inch trap, unless otherwise noted. All ductwork drains shall be piped to the nearest approved floor drain or gutter.

N. All buried ductwork shall be bedded in sand. Sand shall extend a minimum of 6-inches below the bottom of the duct, 12-inches minimum on the sides of the duct, and shall be flush with the top of the duct, unless otherwise noted. Backfill with compacted selected fill in accordance with Section 02315, Excavation and Backfill.

3.3 INSPECTION OF ODOR CONTROL SYSTEM

A. ENGINEER reserves right to reject any and all items of equipment found to have the following: blisters, chips, crazing, exposed glass, dry cracks, burned areas, dry spots, foreign matter, or entrapped air at the laminate surfaces which do not satisfy the tolerances specified in ASTM D 2563 Table 1, acceptance level II for inside and outside surfaces or meet the specified requirements.

3.4 INSPECTION AND START-UP ADJUSTMENTS

A. Perform the following inspection of equipment with the equipment manufacturer's approved representative: Submit the Certification of Inspection to the ENGINEER.
   1. Verify proper equipment mounting and setting.
   2. Verify that control fan, interlock and power wiring each is complete.
   3. Verify alignment of each motor and drive.
   4. Verify proper piping connections and accessories.
   5. Verify that lubrication is completed.
   6. Verify direction of rotation.
   7. Verify setting of safety controls.
   8. Monitor heat build up in bearings.
   9. Check motor loads against manufacturer's nameplate data.
   10. Verify proper starter overload heater sizes.
   11. Verify function of safety and operating controls.
   12. Verify proper operation of equipment.
   13. Verify proper chemical solution sump level.
   14. Verify carbon levels and distribution.
   15. Overall Odor Control System.

B. Start-up Adjustments:
   1. Remove all loose materials and obstructions from interior of ducts and scrubber.
   2. Remove debris and waste materials resulting from installation.
   3. Adjust fan and pumps for proper alignment and flow.
   4. Set volume control devices for approximate positions in preparation for final testing and balancing.
   5. Balance system for CFM indicated.

3.5 FIELD TESTS

A. Qualified field service representative of the manufacturer shall conduct an operating test of the equipment and controls in the presence of ENGINEER to demonstrate that the equipment and its controls will function correctly.
   1. Recirculating Scrubbant and Chemical Feed Systems:
      a. Test, adjust, and balance system in accordance with the following requirements:
         1) Verify pump rotation, test and record pump shut-off head, and test and record pump wide-open head.
         2) Verify proper scrubbant level in scrubber and in the system.
      b. Install valve tags and record necessary information required for valve charts for each valve.
      c. Verification:
         1) Record rated and actual running amperage and voltage.

2) Record total dynamic head for pump.

d. Verify that pH and ORP probes are operable and capable of controlling sodium hypochlorite and sodium hydroxide feed rates. Calibrate and test in accordance with the probe manufacturer's recommendation and in the presence of the ENGINEER.
e. Verify chemical metering pumps are operational in all modes.
f. Verify recirculation pump seal water system is operational.
g. Verify make-up water rotameter is calibrated to proper flow range.
h. Verify operation of differential pressure indicator across scrubber and mist eliminator.
i. Verify operation of scrubber sump level indicator.

2. Drainage System Piping:
   a. Perform tests on entire system.
   b. Tightly close all openings except the highest opening of system to be tested.
   c. Fill system or section with water to point of overflow.
   d. Test with a head of at least ten feet of water.
   e. Allow water to stand in system for at least 15 minutes before inspecting.
   f. Inspect system or sections for leaks, and repair any leaks found. Retest until approved by ENGINEER.

3.6 PERFORMANCE TESTS

General: Conduct performance tests with the equipment manufacturer's approved representative on each multi-stage FRP packaged scrubber system, each carbon adsorber system and on the complete Odor Control System (scrubber and carbon adsorber) after each system has been assembled, field tested and balanced. A 14 day performance demonstration test on the overall Odor Control System is required.

B. Performance tests shall demonstrate conformance to the specified design criteria and that pressure drop through each biofilter odor control system. Provide, as a minimum, the equipment listed below for conducting all Odor Control System testing:
   1. Air velocity measuring duct device with pitot tube or hot wire anemometer with to measure a range of 200 to 5,000 fpm to determine air velocity and cfm in duct.
   2. Tachometer to record motor and fan rpm.
   3. Ammeter to record motor power draw.
   4. Thermometer, range from 0°F to 212°F.
   5. One portable manometer with range of 0 to 10-inch water column for measuring differential pressure across scrubber.
   6. Air sampling pump.

C. Maricopa County Emissions Permit Compliance Testing:
   1. Emissions Permit Compliance Testing shall be conducted after successful completion of the 30 days field tests with wastewater in the system as specified in Paragraph 3.5.A.
   2. The testing will confirm the odor control system has achieved a minimum 99.9 percent hydrogen sulfide removal. The testing will be conducted as specified herein and will be witnessed by the Maricopa County Environmental Services Department, Air Quality Division. Responsible for coordinating the testing with the County. A minimum 30 day advance notice of testing is usually required by the County in order to schedule their personnel. At least 60 days prior to odor control scrubber testing, submit six copies of detailed testing protocol to the ENGINEER, who will review it and return it to CONTRACTOR to address ENGINEER'S comments. After the document has been modified by CONTRACTOR, CONTRACTOR and ENGINEER will meet with the County and will review the protocol as with the County's representative. Make modifications in the protocol as requested by the County.
   3. The odor control system testing methods shall be specified in the appendices to 40 CFR Part 60 and the Maricopa County Air Pollution Control Rules and Regulations (Rules).
   4. Provide the services of an independent consultant (Emissions Consultant) experienced in testing Odor Control System emission air quality for compliance with the requirements of Maricopa County Air Pollution Control Division (MCAPCD). The Emissions Consultant shall have a minimum of five years of odor control experience in emissions air quality testing in Maricopa County, Arizona. Submit the Emission's Consultant's statement of qualifications and experience to the ENGINEER for approval.
   5. The Emissions Consultant shall perform all required testing and prepare a final report to demonstrate that the Odor Control System performs as specified herein, including the emissions requirements established by MCAPCD.
   6. The Emissions Consultant shall be responsible for all testing procedures, to furnish, install, operate and maintain all testing and recording equipment, instruments and controls and to perform on-site calibration of all testing equipment. The Emissions Consultant shall prepare the protocol for a testing plan, secure testing plan approval from MCAPCD, provide written notice of the testing schedule to MCAPCD at least 30 days prior to initiating testing, conduct all tests (allowing the ENGINEER, OWNER and Maricopa County the option to witness the testing) and prepare a test report of the results. In the event that the Odor Control System, as constructed, does not meet the specified performance criteria of Maricopa County, make the required adjustments to the Odor Control System to bring the system into compliance. The Emissions Consultant shall retest the system as often as necessary to meet specified performance requirements.
   7. Ten copies of a final test report suitable for submittal to MCAPCD shall be provided.

3.7 MANUFACTURER'S SERVICES

A. A factory trained representative shall be provided for installation supervision, start-up and test services and operation and maintenance personnel training services. The representative shall make a minimum of 3 visits to the site for a period of 8 hours per visit. The first visit shall be for assistance in the installation of equipment. The second visit shall be for checking the completed installation and start-up of the system. The third visit shall be as described under Section 01821, Instruction of Operations and Maintenance Personnel. Manufacturer's representative shall test operate the system in the presence of the ENGINEER and verify that the Odor Control System conforms to the requirements. Representative shall revisit the job site as often as necessary until all trouble is corrected and the installation is entirely satisfactory.

B. All costs, including travel, lodging, meals and incidentals, shall be considered as included in CONTRACTOR'S bid price.

C. Serviceman shall verify that lubrication systems are complete, clean and filled with the proper grade of lubricants.

D. Additional Inspections - First Year: Every fourth month for twelve months after acceptance of the Odor Control System, manufacturer's factory trained serviceman shall perform an inspection of each system and submit an inspection report to OWNER and ENGINEER.

+ + END OF SECTION + +

SECTION 15050

PIPING SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. This Section specifies systems of process piping and general requirements for piping systems. Detailed Specifications for the components listed on the Piping System Specification Sheets are found in the applicable Sections of Division 15, Mechanical. This Section shall be used in conjunction with those Sections.
   2. Provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish, install and test all piping, fittings and specials. The Work includes, but is not limited to, the following:
      a. All types and sizes of piping, except those specified under other Sections.
      b. Piping beneath, embedded or within structures.
      c. Supports, restraints and thrust blocks.
      d. Pipe encasements.
      e. Work on or affecting existing piping.
      f. Testing.
      g. Cleaning and disinfecting.
      h. Installation of all jointing and gasket materials, specials, flexible couplings, mechanical couplings, harnessed and flanged adapters, sleeves, tie rods and all other Work required to complete the piping installation.
         1) Gasket materials shall comply with National Sanitation Foundation (NSF-61) and Arizona Administration Code requirements as stated in Specification Section 01420 – References.
      i. Incorporation of valves, meters and special items shown on the Drawings or specified into the piping systems as required and as specified in the appropriate Division 15, Mechanical, Sections.
      j. Unless otherwise specifically shown on the Drawings, specified, or included under other Sections, all buried piping Work required begins at the outside face of structures or structure foundations and extending away from structure.

B. Coordination:
   1. Review installation procedures under other Sections and coordinate with the Work that is related to this Section.

C. Definitions:

1. Pressure terms used in this Section and elsewhere in Division 15, Mechanical, are defined as follows:
   a. Maximum: The greatest continuous pressure at which piping system operates.
   b. Test: The hydrostatic pressure used to determine system acceptance.

1.2 QUALITY ASSURANCE

A. Conform to all applicable requirements of Parts 600 and 700 of the Uniform Standard specifications for Public Work Construction by the Maricopa Association of Governments (MAG). If there is a conflict between MAG Standard specifications and these Specifications, the Provisions of these Specifications shall govern.

B. Requirements of Regulatory Agencies:
   1. Comply with requirements of NFPA Standard No. 24 for "Outside Protection" where applicable to water pipe systems used for fire protection.
   2. Comply with applicable requirements of NFPA Standard No. 14 for "Standpipe and Hose Systems" used for fire protection.
   3. Comply with requirements of UL, FM and other jurisdictional authorities, where applicable.
   4. Refer to the General and Supplementary Conditions regarding permit requirements for this Work.
   5. Comply with requirements of Phoenix Construction Code.

C. Reference Standards: Comply with applicable provisions and recommendations of the following, except as otherwise shown or specified.
   1. AASHTO M36/M36M, Metallic (Zinc or Aluminum) Coated Corrugated Steel Culverts and Underdrains.
   2. ANSI A13.1, Scheme for the Identification of Piping Systems.
   3. ANSI B1.20.1, Pipe Threads, General Purpose (Inch).
   4. ANSI B16.1, Cast Iron Pipe Flanges and Flanged Fittings Class 25, 125, 250, and 800.
   5. ANSI B16.3, Malleable Iron Threaded Fittings Class 150 and 300.
   6. ANSI B16.5, Pipe Flanges and Flanged Fittings.
   7. ANSI B16.9, Factory-Made Wrought Steel Buttwelding Fittings.
   8. ANSI B16.11, Forged Steel Fittings, Socket Welding and Threaded.
   9. ANSI B16.12, Cast Iron Threaded Drainage Fittings.
   10. ANSI B16.22, Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
   11. ANSI B16.26, Cast Copper Alloy Fittings for Flared Copper Tubes.
   12. ANSI B31.1, Power Piping.
   13. ANSI B31.3, Chemical Plant and Petroleum Refinery Piping.
   14. ASME SECTION IX, Boiler and Pressure Vessel Code; Welding and Brazing Qualifications.
   15. ASTM A47, Specification for Ferritic Malleable Iron Castings.

16. ASTM A53, Specification for Pipe, Steel, Black and Hot Dipped, Zinc-Coated Welded and Seamless.
17. ASTM A74, Specification for Cast Iron Soil Pipe and Fittings.
18. ASTM A105/A105M, Specification for Carbon Steel Forgings for Piping Components.
19. ASTM A106, Specification for Seamless Carbon Steel Pipe for High-Temperature Service.
20. ASTM A126, Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
21. ASTM A197, Specification for Cupola Malleable Iron.
22. ASTM A234/A234M, Specification for Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures.
23. ASTM A312/A312M, Specification for Seamless and Welded Austenitic Stainless Steel Pipe.
24. ASTM A403/A403M, Specification for Wrought Austenitic Stainless Steel Piping Fittings.
25. ASTM A536, Specification for Ductile Iron Castings.
26. ASTM A570/A570M, Specification for Steel, Sheet and Strip, Carbon, Hot-Rolled, Structural Quality.
27. ASTM B88, Specification for Seamless Copper Water Tube.
28. ASTM C76, Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe.
29. ASTM C296, Specification for Asbestos-Cement Pressure Pipe.
30. ASTM C443-REV A, Specification for Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets.
31. ASTM C564, Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings.
32. ASTM D1248, Specification for Polyethylene Plastics Molding and Extrusion Materials.
33. ASTM D1784, Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
34. ASTM D2241, Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe (SDR-PR).
35. ASTM D2513, Specification for Thermoplastic Gas Pressure Pipe, Tubing, and Fittings.
36. ASTM D2665, Specification for Poly (Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings.
37. ASTM D2996, Specification for Filament-Wound Reinforced Thermosetting Resin Pipe.
38. ASTM D3034, Specification for Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
39. ASTM D3261, Specification for Butt Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.
40. ASTM D3262, Specification for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Sewer Pipe.

41. ASTM D4174, Practice for Cleaning, Flushing, and Purification of Petroleum Fluid Hydraulic Systems.
42. ASTM D4101, Specification for Propylene Plastic Injection and Extrusion Materials.
43. ASTM F441, Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80.
44. AWWA C105, Polyethylene Encasement for Ductile-Iron Piping for Water and Other Liquids.
45. AWWA C110, Ductile-Iron and Gray-Iron Fittings, 3 Inch Through 48 Inch, for Water and Other Liquids.
46. AWWA C111, Rubber-Gasket Joints for Ductile-Iron and Gray-Iron Pressure Pipe and Fittings.
47. AWWA C115, Flanged Ductile-Iron and Gray-Iron Pipe with Threaded Flanges.
48. AWWA C151, Ductile-Iron Pipe, Centrifugally Cast in Metal Molds or Sand-Lined Molds, for Water or Other Liquids.
49. AWWA C200, Steel Water Pipe 6 Inches and Larger.
50. AWWA C205, Cement-Mortar Protective Lining and Coating for Steel Water Pipe--4 In. and Larger--Shop Applied.
51. AWWA C206, Field Welding of Steel Water Pipe.
52. AWWA C207, Steel Pipe Flanges for Waterworks Services--Sizes 4 In. through 144 In.
53. AWWA C208, Dimensions for Fabricated Steel Water Pipe Fittings.
54. AWWA C209, Cold-Applied Tape Coating for special sections, Connections, and Fittings for Steel Water Pipelines.
55. AWWA C210, Liquid Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipe.
56. AWWA C214, Tape Coating Systems for the Exterior of Steel Water Pipelines.
57. AWWA C301, Prestressed Concrete Pressure Pipe, Steel Cylinder Type, for Water and Other Liquids.
58. AWWA C303, Reinforced Concrete Pressure Pipe-Steel Cylinder Type, Pretensioned, for Water and Other Liquids.
59. AWWA C600, Installation of Ductile-Iron Water Mains and Their Appurtenances.
60. AWWA C651, Disinfecting Water Mains.
61. AWWA C900, Polyvinyl Chloride (PVC) Pressure Pipe, 4 Inches Through 12 Inches, for Water.
62. AWWA M11, Steel Pipe-A Guide for Design and Installation.
63. CISPI 301, specification Data for Hubless Cast Iron Sanitary System with No-Hub Pipe and Fittings.
64. FEDSPEC L-C-530B(1), Coating, Pipe, Thermoplastic Resin or Thermosetting Epoxy.
65. MIL-H-13528B, Hydrochloric Acid, Inhibited, Rust Removing.
66. MIL-STD-810C, Environmental Test Methods.

67. SAE J1227, Assessing Cleanliness of Hydraulic Fluid Power Components and Systems.
68. Phoenix Plumbing Code.
69. Phoenix Construction Code.
70. National Sanitation Foundation (NSF-61) and Arizona Administration Code requirements as stated in Specification Section 01420 – References.

D. Fitting and Coupling Compatibility:
   1. To assure uniformity and compatibility of piping components, fittings and couplings for grooved end piping systems shall be furnished by the same manufacturers.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Detailed drawings and data on pipe, fittings, gaskets and appurtenances. Submit these with Shop Drawings required under Section 15050, Piping Systems, Section 15051, Buried Piping Installation, and Section 15052, Exposed Piping Installation.

B. Certificates: Submit certificates of compliance with Referenced Standards.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING

A. General:
   1. Deliver materials to the site to ensure uninterrupted progress of the Work.
   2. Handle all pipe, fittings, specials and accessories carefully with approved handling devices. Do not drop or roll material off trucks. Do not otherwise drop, roll or skid piping.
   3. Store pipes and fittings on heavy wood blocking or platforms so they are not in contact with the ground.
   4. Unload pipe, fittings and specials opposite to or as close to the place where they are to be installed as is practical to avoid unnecessary handling. Keep pipe interiors completely free from dirt and foreign matter.
   5. Inspect delivered pipe for cracked, gouged, chipped, dented or other damaged material and immediately remove defective pipe from site.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Unless otherwise specified, piping materials, including pipe, gaskets, fittings, connection and joint assemblies, linings and coatings, shall be selected from those listed on the Piping System Specification Sheets. Piping materials shall conform

to detailed Specifications for each type of pipe and piping appurtenances specified in the applicable Sections of Division 15, Mechanical.

B. Materials or products which can contact drinking water as part of a water treatment process or water supply system including but not limited to pipe, gaskets, fittings, linings, coatings, etc., must comply with National Sanitation Foundation (NSF-61) and Arizona Administration Code requirements as stated in Specification Section 01420 – References.

2.2 PIPING IDENTIFICATION

A. Marking Piping:
   1. Clearly mark each piece of pipe or fitting with a designation conforming to that shown on the approved Shop Drawings.
   2. Cast or paint material, type and pressure designation on each piece of pipe or fitting 4-inches in diameter and larger.
   3. Pipe and fittings smaller than 4-inches in diameter shall be clearly marked by manufacturer as to material, type and rating.
   4. Markers bearing the legends on the background colors specified in Section 09900, Painting, and shall be provided in the following letter heights:

Outside Pipe Diameter [a], (inches)	Letter Height, (inches)
Less than 1-1/2	1/2
1-1/2 through 3	1-1/8
Greater than 3	2-1/4

[a] Outside pipe diameter shall include insulation and jacketing.

In addition, pipe markers shall include uni- and bi-directional arrows in the same sizes as the legend. Legends and arrows shall be white on blue or red backgrounds and black on other specified backgrounds.

B. Plastic Tracer Tape: Tracer tape shall be 6-inches wide, colored the same as the background colors as specified in Section 09900, Painting, and made of inert plastic material suitable for direct burial. Tape shall be capable of stretching to twice its original length and shall be as manufactured by Allen Systems, W. H. Brady Co., Seton Name Plate Corporation, Marking Services Inc., or equal.
   1. Two messages shall be printed on the tape. The first message shall read "CAUTION CAUTION CAUTION _____ PIPE BURIED BELOW" with bold letters approximately 2-inches high. The blank shall be filled with the particular system fluid such as chlorine, oxygen or sulfur dioxide. The second message shall read, "CALL _____" with letters approximately 3/4-inch high. The blank shall be filled in with the plant telephone number. Both messages shall be printed at maximum intervals of two feet.

C. Magnetic Tracer Tape: Polyethylene magnetic tracer tape shall be as manufactured by Allen Systems, W.H. Brady Co., Seton Name Plate Corporation, Marking Services, Inc., or equal. Tape shall be acid and alkali-resistant, 3-inches wide, 0.005-inch thick, and have 1500-psi strength and 140 percent elongation value. The tape shall be colored the same as the background colors as specified in Section 09900, Painting, and shall be inscribed with the word "CAUTION – PIPE BURIED BELOW" and the name of the piping system.

2.3 VALVES

A. Valves of the same size and service shall be provided by a single valve manufacturer. Packing shall be non-asbestos material. Actual length of valves shall be within 1/16-inch (plus or minus) of the manufacturer's specified length. Flanges shall meet the requirement of ANSI B16.5. Push-on and mechanical joints shall meet the requirements of AWWA C111 and conform to the requirements of Section 15051, Buried Piping Installation.

PART 3 - EXECUTION

3.1 INSTALLATION - GENERAL

A. Location:
   1. Piping shall be provided as specified, except for adjustments to avoid architectural and structural features and shall be coordinated with electrical construction.

B. Piping Sizes:
   1. Where the size of piping is not shown on the Drawings or specified, provide piping of the sizes required by UPC. Unless specified otherwise, small piping (less than 1-inch in diameter) required for services not described by UPC shall be 1/2-inch.

C. Pipe Support, Anchorage and Seismic Bracing:
   1. Piping shall be supported by anchor brackets, guides, saddles or hangers. Acceptable types of supports, guides, saddles, hangers and structure attachments for general pipe support, expansion/contraction and for seismic bracing, as well as anchorage details, are shown on the Drawings. Minimum spacing shall be as specified for supports and for seismic bracing. Where a specific type of support or anchorage is shown on the Drawings, then only that type shall be used there. Piping shall be vertically supported by anchor brackets, guides, saddles or hangers and shall be seismically braced where indicated to resist lateral load. Supports shall be provided on each run at each change of direction. Pipe supports, components and hardware shall be Type 304L stainless steel. Unless otherwise specified, existing pipes and supports shall not be used to support new piping.

2. Pipe shall be supported, alignment and installed in such a way so as not to impose undue stress/forces to couplings, connections, supports, valves, equipment and instruments.

D. Thrust Restraint:
   1. General: All plugs, caps, tees and bends in buried pressure piping systems shall be anchored by means of reaction backing or restrained joints as specified.
   2. Restrained Pipe Joints: Pipe joints shall be restrained by means suitable to the type of pipe being installed.
      a. Ductile-iron push on joints and mechanical joints shall be restrained utilizing a proprietary restrained joint system such as:
         1) American Loc-Ring or Flex-Ring
         2) Clow Super-Lock Joint
         3) EBBA Iron Sales Inc. Megalug
         4) U.S. Pipe TR Flex Joint
         5) Or Equal
      b. Steel pipe shall have welded joints, flanged joints, or flexible or mechanical coupling connectors as specified in Section 15102, Steel Pipe. Tie rods connected to ears welded to the steel pipe shall be provided for restraint at all flexible coupling connectors.
      c. Thermoplastic and copper piping shall generally be installed with soldered, solvent weld, threaded, flanged, or similar type joints. Where push-on type or other non-restrained joints are provided, provide tie rods or other suitable joint restraint system for these joints, subject to the approval of ENGINEER.
      d. Harnessed lengths for pipe shall be determined by the pipe manufacturer in accordance with the formula in Section 15051, Buried Piping Installation, for determination of harnessed lengths.
      e. Restrain ductile iron pipe connected to flexible couplings or flanged coupling adapters by harnessing across the coupling or adapter using tie rods or extended bolts connecting between flanges.
   3. Concrete Thrust Blocks and Anchor Blocks:
      a. Thrust blocks and anchors shall be constructed of Class B concrete.
      b. Blocks shall be placed against undisturbed soil and sized as shown on the Drawings or as directed by the ENGINEER. Concrete shall be placed so that pipe joints and fitting joints will be accessible for repair.

E. Manufacturer's Installation Specialist:
   1. Provide the services of a competent installation specialist of the pipe manufacturer when pipe laying begins, if CONTRACTOR is not experienced in laying and jointing a particular type of pipe.
   2. Retain installation specialist at the site for a minimum of two days or until competency of the pipe laying crew has been satisfactorily demonstrated.

F. Bedding and Backfill:

1. Bedding and backfill for buried piping shall conform to the requirements of Section 15051, Buried Piping Installation.

3.2 PIPING IDENTIFICATION

A. Pipe Coding:
   1. After application of the specified coating and insulation systems, exposed piping, interior and exterior, and piping in ceiling spaces, pipe trenches, pipe chases and valve boxes shall be identified with painted bonding and lettering as specified in Article 2.2, above. Legend markers and directional arrows shall be located at each side of walls, floors and ceilings, at one side of each piece of equipment, at piping intersections, and at approximately 25-foot centers.

B. Plastic Tracer Tape:
   1. A single line of tape as specified in Paragraph 2.2.B., above, shall be provided 2.5 feet above the centerline of buried ferrous pipe. For pipelines buried eight feet or greater below finished grade, provide a second line of tape 12-inches below finished grade, above and parallel to each buried pipe. Tape shall be spread flat with message side up before backfilling.

C. Magnetic Tracer Tape: Polyethylene magnetic tracer tape shall be buried 12 to 18-inches below finished grade and shall be above and parallel to buried non-ferrous, plastic and reinforced thermosetting resin pipe lines. For pipelines buried eight feet or greater below finished grade, provide a second line of tape 2.5 feet above and parallel to each buried pipe.

3.3 VALVE IDENTIFICATION

A. Provide CMMS Tags for valves as specified under Section 01630, Computerized Maintenance Management System Tags, and as shown on the drawings.

3.4 WORK AFFECTING EXISTING PIPING

A. Location of Existing Piping:
   1. Locations of existing piping shown on the Drawings should be considered approximate.
   2. Determine the true locations of existing piping to which connections are to be made, and locations of other facilities which could be disturbed during earthwork operations, or which may be affected by CONTRACTOR'S Work already installed.
   3. Conform to applicable requirements of Division 1, General Requirements, pertaining to cutting and patching and connections to existing facilities.

B. Taking Existing Pipelines Out of Service:

1. Do not take pipelines out of service, unless specifically listed below, or approved by ENGINEER.
   a. Refer to Section 01143, Coordination with OWNER'S Operations.
2. Notify ENGINEER at least 48 hours prior to taking pipeline out of service.

C. Work on Existing Pipelines:
1. Cut or tap pipes as shown on the Drawings or required, with machines specifically designed for this Work.
2. Install temporary plugs to prevent entry of mud, dirt, water and debris.
3. Provide all necessary adapters, fittings, pipe and appurtenances required to complete the Work.
4. Existing pipelines which are cut and abandoned shall be adequately capped or filled with grout.

3.5 TESTING

A. General:
1. Upon completion of piping, but prior to application of insulation on exposed piping, test the piping systems. Pressures, media and test durations shall be as specified in Article 3.7, below. Equipment which may be damaged by the specified test conditions shall be isolated. Testing shall be performed using calibrated test gages and calibrated volumetric measuring equipment to determine leakage rates. Each test gage shall be selected so that the specified test pressure falls within the upper half of the gage's range. Unless otherwise specified, notify the ENGINEER 24 hours prior to each test.
2. Unless otherwise specified, testing, as specified herein, shall include existing piping systems which connect with new piping systems. Existing pipe shall be tested to the nearest existing valve. Any piping which fails the test shall be repaired. Repair of existing piping will be considered and paid for as extra work.
3. Where testing existing chlorine and sulfur dioxide systems to the nearest isolation valve, provide a tee in the line adjacent to the valve. The branch outlet on the tee shall be valved and used for cleaning, pressure testing, draining, and drying the line. Unless otherwise indicated, the existing chlorine or sulfur dioxide system shall not be shut down during testing or connecting the tee and valve. Prior to placing the line in service, the valve on the branch outlet shall be plugged or sealed with a blind flange or threaded plug. Responsibility belongs to CONTRACTOR for all damage to the existing system as a result of this work.

B. Gas, Air, and Vapor Systems:
1. Test steam lines hydrostatically in accordance with the ASME procedure for testing pressure piping.
2. Testing medium and procedures for chlorine systems are specified in Paragraph 3.5.D., below.

3. Unless otherwise specified, the testing medium for other gas, air and vapor systems shall be as follows:

Pipeline size	Specified Test Pressure	Testing medium
2-inch and smaller	75 psi or less	Air or water
2-inch and smaller	Greater than 75 psi	Water
Greater than 2-inch	3 psi or less	Air or water
Greater than 2-inch	Greater than 3 psi	Water

4. Potable Water Systems Additional Requirements:

   a. The CONTRACTOR shall provide all vents, piping, plugs, bulkheads, valves, bracing, blocking, pump, including measuring device and all other equipment necessary for making the tests, except pressure gages.
   b. The pipe shall be tested between each valve or between a valve and the closed end of the pipe.
   c. Pipe test section shall be limited to 1/2 linear mile, or less, unless otherwise approved in writing by the Engineer. Testing cannot be done against an existing valve. The new pipeline must be separated from any potable system in such a way to prevent any potential for cross-contamination between the existing potable water system and the new pipeline.
   d. The test shall be made after the backfilling is completed or compacted, regardless of the compaction method.
   e. All connections, blow-offs, hydrants and valves shall be tested with the main, where practical.
   f. The test section shall be slowly filled with potable water and all air shall be vented from the line. The rate of filling shall be as approved by the Superintendent of Water Distribution, with at least 24-hour notice required before filling is scheduled.

C. Liquid Systems:
   1. Leakage shall be zero at the specified test pressure throughout the specified duration for the following systems: Exposed piping, buried piping, and buried or exposed piping carrying liquid chemicals. Unless otherwise specified, leakage from other buried liquid piping systems shall be less than 0.02 gallon per hour per inch diameter per 100 feet of buried piping.

D. Chlorine Systems:
   1. General: Chlorine systems comprise of chlorine, in gaseous and liquid phase, under positive and negative pressure. After cleaning, as specified in Paragraph 3.6.E., below, the system shall be pressure tested. Pressure gages, relief valves, automatic control valves, and other components which may be damaged or exceeded by test pressures shall be removed and openings shall be blocked off prior to testing. Do not attempt to repair leaks until all

pressure has dissipated from the system. The system shall be repaired and retested, as necessary, until a successful test (zero leakage) is achieved.

a. For evaporator-supplied systems, disconnect the vent from the discharge side of the pressure relief valve of each evaporator, plug the resultant opening, inspect and secure all joints, close all valves which discharge to atmosphere, and open all in-line valves. Open the valve in the bypass line around the pressure reducing valve on the downstream side of each evaporator to provide a through path around this valve. System piping shall then be tested to 150 psig. After testing, replace all equipment previously removed and close all in-line valves. Reconnect the vent line to the downstream side of the pressure relief valve of each evaporator and close the valve in the bypass line around the pressure reducing valve on the downstream side of each evaporator.

b. Steel pipelines shall be hydrostatically tested. However, if drying after hydrostatic testing is impractical or cannot be accomplished, test steel lines with nitrogen gas or dry air providing, that all the necessary safety precautions to safeguard personnel and minimize the risk incurred when performing such a test at high pressures have been taken. All CPVC pipelines shall be hydrostatically tested. Testing CPVC lines with nitrogen or air is not permitted.

2. Hydrostatic Testing: Steel piping lines and CPVC solution lines hydrostatically tested shall be tested to 150 psig. CPVC vacuum lines shall be hydrostatically tested to 50 psig. After testing, all moisture absorbing gaskets and valve packing shall be replaced.

3. Drying: Chlorine piping systems shall be dried prior to placing in service. Even if water has not been purposely introduced into the system for hydrostatic testing or cleaning, drying is still required because moisture may enter the system from the atmosphere or other sources.

   a. For steel pipe, drying shall be accomplished by passing steam through the lines from the high end of the system until the lines are thoroughly heated. While steaming, allow condensate and foreign matter to drain out. The steam supply shall then be disconnected and all pockets and low spots in the line drained. While the line is still warm, dry oil-free air having a dew point of -40°F, or below, shall be blown through the line until the exiting air dew point is the same as the supply air. Valves shall be fixed in the half-open position during drying. Valves removed temporarily from the system during drying operations must be free of moisture before being recoupled to the piping system.

   b. Drying of CPVC pipe applies solely to vacuum lines and consists of draining and removing all water and moisture from the system. After draining the line, first "pig" the pipe to remove excess water. Then air dry the system in accordance with the requirements for steel pipe. CPVC pipe shall not be steamed.

4. Nitrogen or Air Pressure Testing: May use nitrogen gas or oil-free dry air to test steel lines. Testing consists of gradually introducing nitrogen gas or dry air up to 50 psig and maintaining this pressure while testing the line for leaks

with soapy water. When the system is free from leaks at this pressure, the test pressure shall then be increased in increments of 50 psig up to a maximum of 150 psig. At each stepped increase in pressure, check for leaks and take corrective action as necessary. When the system is free from leaks at the final test pressure, the system shall then be depressurized, the test source disconnected, and the system capped to prevent the entrance of water.

a. For testing with nitrogen gas, use cylinders of dry high purity nitrogen gas, nitrogen handling cylinder mounted pressure regulator 0 to 300 psig, and necessary fittings and adapters to complete connection between the source and system header. Pressure regulator shall be self-relieving type, which vents to the atmosphere, and includes a throttling valve.
b. For testing with air, provide oil-free air with a relative humidity of zero. All fittings, adapters, and accessories, pressure regulator and throttling valve shall be suitable for pressure testing with air and rated for 300 psig service.

5. Service Gas Testing: Immediately after the chlorine system has been dried and pressure tested, the service gas shall be gradually introduced and the entire system tested for leaks. Time shall be allowed for the complete replacement of air from the piping with service gas.
   a. Use a liquid ammonia solution or chlorine gas detector to detect for chlorine leaks. Spray the solution at the pipe connections and shall not squirt the liquid on the pipe or fittings. In the event leaks are detected in the piping or the equipment, they shall not be repaired until all gas has been purged from the line. The reaction of the two substances produces a dense white cloud. Upon completion of repairs, repeat the cleaning and drying process described in this Paragraph and in Paragraph 3.6.E., below, and retest the lines with service gas.

E. Hydraulic and Lube Oil Systems:
   1. Upon completion of cleaning, all field connections shall be completed and the system tested at the specified pressure. Pressure loss shall be zero for the specified test period. For fluid power systems, the manufacturer shall supervise the installation and testing of all system components including all field piping.

F. Drains:
   1. Drain systems, other than pumped drain systems, shall be tested in accordance with Phoenix Plumbing Code.

G. Diesel Fuel:
   1. Upon completion of cleaning, all field connections shall be completed and the system tested at the specified pressure. Pressure loss shall be zero for the specified test period.

3.6 CLEANING AND FLUSHING

A. General:

1. Piping systems shall be cleaned following completion of testing and prior to connection to operating, control, and regulating or instrumentation equipment. At CONTRACTOR'S option, may clean and test sections of the buried or exposed piping systems. Use of this procedure; however, will not waive the requirement for a full pressure test of the completed system. Unless specified otherwise, piping 24-inches in diameter and smaller shall first be cleaned by pulling a tightly fitting cleaning ball or swab through the system. Piping larger than 24-inches in diameter may be cleaned manually or with a cleaning ball or swab.

B. Temporary Screens:
1. Upon completion of the cleaning, connect the piping systems to related process equipment. Temporary screens, provided with locator tabs which remain visible from the outside when the screens are in place, shall be inserted in pipelines at the suction of pumps and compressors in accordance with the following table:

Equipment Suction Or Piping Size, (Inches)	Maximum Screen Opening, (Inches)
0 to 1	1/16
1-1/4 to 3	1/4
3-1/2 to 6	1/2
Over 6	1

2. Maintain the screens during testing, initial start-up, and initial operating phases of the commissioning process. In special cases, screens may be removed as required for performance tests. Remove the temporary screens and make the final piping connections after the screens have remained clean for at least 24 consecutive hours of operation. Systems handling solids are exempted.

C. Gas and Air Systems:
1. Unless otherwise specified, gas and air system piping 6-inches in diameter and smaller shall be blown out, using air or the testing medium specified. Piping larger than 6-inches shall be cleaned by having a swab or "pig" drawn through the separate reaches of pipe. After connection to the equipment, it shall then be blown out using the equipment. Upon completion of cleaning, the piping shall be drained and dried with an airstream. Propane systems shall be purged with nitrogen and a nitrogen pad maintained at 10 psi until put in service. Sludge gas systems shall be purged with nitrogen and a nitrogen pad maintained at 3 psi until put in service.

D. Liquid Systems:
1. After completion of cleaning, liquid systems, unless otherwise specified, shall be flushed with clean water. With temporary screens in place, the liquid

shall be circulated through the piping system using connected equipment for a minimum period of 15 minutes and until no debris is collected on the screens.

E. Chlorine Systems:
   1. General: All portions of the system shall be cleaned free of oil and grease.
   2. Steel Pipe: All pipe threads shall be washed clean and free from cutting oil. The inside of all pipe sections and fittings shall be cleaned of any pipe dope, oil and grease by drawing a cloth wetted with solvent through each assembly. Valves shall be dismantled, thoroughly cleaned with solvents, and repacked, if necessary. Cap or plug all open ends at the end of each day's Work.
      a. Use carbon tetrachloride or trichloroethylene. At all times exercise caution to minimize solvent exposure and shall be responsible for its proper handling and disposal. Solvents containing hydrocarbons or alcohols are unacceptable.
   3. CPVC Pipe: All solution lines shall be cleaned using water only. Vacuum lines shall be cleaned with a detergent and water and thoroughly rinsed to remove all vestiges of detergent. All lines shall be further purged of water by passing a cleaning ball or swab through the lines as specified in Paragraph 3.6.A., above.

F. Steam Systems:
   1. Before the steam system is put into service, cleaning shall be performed to remove such contaminants as mill scale, weld scale, corrosion products, oil, grease, dust and dirt. Cleaning shall include a water flush performed at a velocity not less than two feet per second, steam blowdown, and an alkaline flush boilout of the boiler.
   2. After flushing as indicated above, the boiler shall be treated with a caustic compound such as sodium triphosphate, soda ash, sodium tripolyphosphate, or caustic soda. The cleaning process shall be in accordance with steam system cleaning schemes developed by Dowell, the Mogul Division of Dexter Corp., Bentz Entec, or equal.
   3. After cleaning and flushing, and prior to continuous operation of the steam system, adequate corrosion protection shall be provided by maintaining the system full of steam or potable water. If continuous operation does not occur within 60 days after cleaning and flushing, the steam or potable water shall be treated with an acceptable corrosion inhibiting chemical to ensure adequate corrosion protection of the steam system.

G. Hydraulic and Fluid Power Oil Systems:
   1. Upon completion of all field piping, but before connection to any control components, hydraulic and fluid power oil systems shall be flushed and cleaned by circulating special flushing oil through the system. Flushing oil and procedures shall comply with ASTM D 4174. System shall be cleaned such that internal contamination of system, when tested using procedures

specified in SAE J1227, Section 2.3, shall not exceed the Allowable Cleanliness Level (ACL). Unless otherwise specified, the ACL value shall be established by the manufacturer of the major hydraulic system components in accordance with SAE J1227, Section 9.1. System supplier shall provide Certificate of Compliance as required in Paragraph 1.3.B., above, that the ACL has been met.

H. Potable Water Systems:
   1. Potable water piping systems shall be flushed and disinfected in accordance with AWWA C651.

3.7 PIPING SPECIFICATION SHEET

A. General:
   1. Piping and valves for groupings of similar plant processes or types of service lines are specified on individual Piping Specification Sheets. Piping systems are grouped according to the chemical and physical properties of the fluid conveyed and/or by the temperature or pressure requirements. Each grouping of systems is identified by a piping system number. Piping systems specified on the Drawings are numerically arranged by system as shown in Table A. Table A also indicates the system number and fluid category for each service.
      a. Manual air vents shall be provided at the high points of each reach of pipeline where specified. Air vents shall consist of bronze cock and copper tubing return. Air vents shall be taken to the nearest floor with cock mounted four feet above the floor. Vents in piping systems for fluids containing solids shall be 1-inch nonlubricated eccentric plug valves fitted with quick couplers.
      b. Drains shall be piped to a sump, gutter, floor drain or other collection point with a valve mounted four feet above the floor. Drain valves shall be threaded end gate valves of the size specified or as shown on the Drawings. When drains cannot be run to collection points, they shall be routed to a point of easy access and shall have hose gate valves of the size specified.

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Table A - Piping Systems

Article No.	System No.	Symbol	Service Descriptions	Fluid Category
3.8	1	AR	Process Air	Air
3.9	1A	AR	Process Air (drop legs, channel air)	Air
	1A	HPA	High Pressure Air (inside grit basins)	Oxygen
3.10	2	HPA	High Pressure Air	Air
3.11	2A	PCA	Plant Compressed Air	Air
3.12	3	STA	Starting Air	Air
3.13	4	GC	Gas Circulation	Gas
	4	MG	Mixed Gas	Gas
3.14	4A	DG	Digester Gas	Gas
3.15	5	FPL	Flare Propane Pilot Light	Gas
3.16	5A	SDG	Scrubbed Digester Gas	Gas
3.17	6	DIW	Deionized Water	Water
	6	DW	Distilled Water	Water
3.18	7	CW	Domestic Cold Water	Water
	7	PW	Potable Water	Water
3.19	8	CHWR	Chilled Water Return	Water
	8	CHWS	Chilled Water Supply	Water
	8	HWR	Hot Water Return	Water
	8	HWS	Hot Water Supply	Water
	8	HFW	Hot Flushing Water	Water
3.20	9	CWR	Cooling Water Return	Water
	9	CWS	Cooling Water Supply	Water
	9	RW	Reuse Water	Water
	9	GW	Groundwater	Water
3.21	9A	SRW	Service Water	Water
	9A	NPW	Non Potable Water	Water
3.22	10	BS	Brine Solution	Water
	10	SNPW	Softened Non Potable Water	Water
	10	SNPWV	Softened Non Potable Water Vent	Water
3.23	11	SWR	Seal Water	Water
3.24	12	D	Drain	Drain/Vent
	12	DW	Dewatering	Wastewater
	12	ML	Mixed Liquor	Wastewater
	12	PI	Primary Influent	Wastewater
3.25	12A	PD	Process Drain	Wastewater
3.26	12B	SPD	Sump Pump Discharge	Wastewater
3.27	13	FM	Forcemain	Wastewater
	13	PE	Primary Effluent	Wastewater
3.28	13A	CEFF	Chlorinated Effluent	Wastewater
	13A	SE	Secondary Effluent	Wastewater

Article No.	System No.	Symbol	Service Descriptions	Fluid Category
3.29	13B	IMLR	Intermediate Mixed Liquor Recycle	Wastewater
3.30	14	RAS	Return Activated Sludge (14-inches to 36-inches larger)	Sludge
	14	RAS	Return Activated Sludge (42-inches and larger)	Sludge
	14	SC	Secondary Scum (12-inches and smaller)	Sludge
	14	SL	Sludge (2-inches and smaller)	Sludge
	14	WAS	Waste Activated Sludge (12-inches and smaller)	Sludge
3.31	14A	TSL	Thickened Sludge	Sludge
	14A	SL	Sludge (10-inches and smaller, digester drawoff line, digester sludge recirculation)	Sludge
	14A	HSL	Heated Sludge	Sludge
	14A	DS	Digested Sludge	Sludge
	14A	ASL	Alternate Sludge	Sludge
	14A	TPS	Thickened Primary Sludge	Sludge
	14A	UTPS	Unthickened Primary Sludge	Sludge
	14A	WAS	Waste Activated Sludge (WAS Centrifuge Feed Pump Station and Solids Thickening Facility)	Sludge
3.32	14B	SCK	Sludge Cake	Sludge
3.33	14C	SL	Sludge (drawoff inside digester)	Sludge
3.34	15	GCEN	Gravity Centrate	Sludge
3.35	15A	DOF	Digester Overflow	Sludge
3.36	16	PSL	Primary Sludge	Sludge/Scum
	16	PC	Primary Scum (12-inches and smaller)	Sludge/Scum
	16	SMP	Sample (4-inches and larger)	Sludge/Scum
3.37	17	GR	Grit	Grit Slurry
3.38	17A	GD	Grit (dewatering)	Grit Slurry
3.39	17B	GC	Grit Cleaning	Grit Slurry
3.40	18	DSF	Diesel Fuel	Petroleum
	18	GAS	Gasoline	Petroleum
	18	GAV	Gas Vapor Return	Petroleum
	18	LO	Lube Oil	Petroleum
	18	LOR	Lube Oil Return	Petroleum

Article No.	System No.	Symbol	Service Descriptions	Fluid Category
	18	LOS	Lube Oil Supply	Petroleum
	18	LOW	Lube Oil Waste	Petroleum
	18	VP	Petroleum Vent	Petroleum
3.41	19	CLS	Chlorine Solution	Chemical
	19	HCL	Hydrochloric Acid	Chemical
	19	NAOCL	Sodium Hypochlorite	Chemical
	19	CAS	Caustic Soda	Chemical
	19	VCEN	Centrate Vent	Chemical
	19	SPD	Sump Pump Discharge (Area 80 only)	Wastewater
	19	SMP	Sample (3-inches and smaller)	Sludge
3.42	20	CG	Chlorine Gas	Chemical
3.43	21	CGV	Chlorine Gas (vacuum)	Chemical
3.44	21A	DCCN	Dual Contained Calcium Nitrate	Chemical
		FEC	Ferric Chloride	Chemical
3.45	21B	FEC	Ferric Chloride (to influent junction structure)	Chemical
3.46	21C	HCL	Hydrochloric Acid (for scrubber system)	Chemical
3.47	21D	HCL	Hydrochloric Acid (piping in trench)	Chemical
3.48	22	FA	Foul Air	Foul Air
	22	FAD	Foul Air Duct	Foul Air
3.49	23	VA	Vacuum	Vacuum
3.50	24	SW	Sanitary Waste	Drain/Vent
	24	STDR	Storm Drain	Drain/Vent
	24	V	Vent	Drain/Vent
	24	RD	Roof Drain	Drain/Vent
	24	NSD	Non-Sanitary Drain	Drain/Vent
3.51	25	CD	Chemical Drain	Drain/Vent
	25	VC	Chemical Vent	Drain/Vent
3.52	25A	DL	Drain Line (chemical handling facility pressure drains)	Drain/Vent
3.53	26	BCTL	Low Pressure Boiler Chemical	Steam
	26	BCTM	Medium Pressure Boiler Chemical	Steam
	26	BDL	Low Pressure Boiler Blowdown	Steam
	26	BDM	Medium Pressure Boiler Blowdown	Steam
	26	BFL	Low Pressure Boiler Feedwater	Steam
	26	BFM	Medium Pressure Boiler Feedwater	Steam
	26	CL	Low Pressure Condensate	Steam
	26	CM	Condensate, Medium Pressure	Steam
	26	STML	Low Pressure Steam	Steam
	26	STMM	Medium Pressure Steam	Steam
	26	VSL	Low Pressure Steam Vent	Steam

Article No.	System No.	Symbol	Service Descriptions	Fluid Category
	26	VSM	Medium Pressure Steam Vent	Steam
3.54	27	STM	Steam	Steam
3.55	28	JWR	Jacket Water Return	Water
	28	JWS	Jacket Water Supply	Water
3.56	29	HOH	High Pressure Hydraulic Oil	Petroleum
3.57	30	EE	Engine Exhaust	Air
3.58	31	MA	Methyl Alcohol	Chemical
3.59	31A	MAS	Methyl Alcohol Solution	Chemical
3.60	32	OCD	Odor Control Drain	Drain/Vent
	32	SBD	Scrubber Blowdown	Drain/Vent
3.61	32A	SAS	Scrubber Air Sampling	Air
3.62	32B	RECIRC	Scrubber Recirculation Piping	Chemical
3.63	33	DP	Diluted Polymer	Chemical
	33	POL	Polymer	Chemical
3.64	34	CEN	Centrate	Sludge
		CEN-EFF	Centrate Treatment Facility Effluent	Sludge
		CEN-SE	Centrate Treatment Facility Secondary Effluent	Sludge
		DEC	Decant	Sludge
3.64	35	CEN-RAS	Centrate Treatment Facility Return Activated Sludge	Sludge
		CEN-ML	Centrate Treatment Facility Mixed Liquor Suspended Solids	Sludge
		CEN-WAS	Centrate Treatment Facility Waste Activated Sludge	Sludge
		CEN-SCUM	Centrate Treatment Facility Scum	Sludge

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3.11 SYSTEM - 2A

Piping Symbol/Service:	PCA	Plant Compressed Air	
Test Requirements:	Medium:	Refer to Paragraph 3.5.B., above.	
	Pressure:	200 psig for piping 3-inches and smaller. 100 psig for piping 4-inches and larger.	
	Duration:	120 minutes.	
Gasket Requirements:	Flange:	N/A.	
	Push-on/Mech Cpl:	N/A.	
Exposed Pipe/Valves:			
3-inches and smaller	Pipe:	Copper Tube:	Type L. Refer to Section 15105, Copper Pipe, and Section 15217, Compressed Air Piping Systems.
		Conn:	Soldered type, screwed adapters for valve.
		Ftgs:	Refer to Section 15217, Compressed Air Piping Systems.
3-inches and smaller	Valves:	Refer to Section 15217, Compressed Air Piping Systems.	
Buried and Encased Pipe/Valves:			
3-inches and smaller	Pipe:	Copper Tube:	Type K. Refer to Section 15105, Copper Pipe and Section 15217, Compressed Air Piping Systems.
		Conn:	Solder type, flanged adapters for valves.
		Ftgs:	Refer to Section 15217, Compressed Air Piping Systems.
3-inches and smaller	Valves:	Refer to Section 15217, Compressed Air Piping Systems.	
4-inches and larger	Pipe:	Steel:	With polyethylene tape coating. Field application of coating to all couplings. Refer to Section 15102, Steel Pipe.

3.11 SYSTEM - 2A (CONTINUED)

Piping Symbol/Service: PCA Plant Compressed Air

		Conn:	Butt weld, flanged adapters for valves.
		Ftgs:	Refer to Section 15102, Steel Pipe.
4-inches and larger	Valves:	Refer to Section 15217, Compressed Air Piping Systems.	

Remarks:
1. Refer to Drawings for pipe size and valve type. Omit coating on encased pipe.

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3.18 SYSTEM – 7

Piping Symbol/Service:	CW	Domestic Cold Water
	PW	Potable Water

Test Requirements:	Medium:	Water: Refer to Paragraph 3.5.C., above.	
	Pressure:	Refer to Section 15144, Testing of Plumbing Piping Systems: 200 psig for exposed ductile iron pipe, otherwise 125 psig.	
	Duration:	60 minutes.	
Gasket Requirements:	Flange:	Refer to Section 15101, Ductile Iron Pipe. Refer to Section 15106, Thermoplastic Pipe.	
	Push-on/Mech Cpl:	Refer to Section 15101, Ductile Iron Pipe.	
Exposed Pipe/Valves:			
3-inches and smaller	Pipe:	Copper Tube:	Type K (rigid). Refer to Section 15105, Copper Pipe and Section 15141, Potable Water Piping System.
		Conn:	Solder type with threaded or flanged adapters for valves.
		Ftgs:	Refer to Section 15105, Copper Pipe.
2-inches and smaller	Valves:	Refer to Section 15141, Potable Water Piping System.	
4-inches and larger	Pipe:	Ductile Iron:	Class 53 with cement mortar lining. Refer to Section 15101, Ductile Iron Pipe.
		Conn:	Grooved mechanical pipe coupling or flanged.
		Ftgs:	Refer to Section 15101, Ductile Iron Pipe, ends and lining to match pipe.
2-1/2-inches and larger	Valves:	Butterfly:	Refer to Section 15111, Butterfly Valves, Operators and Appurtenances.
		Swing Check:	Refer to Section 15114, Check Valves and Appurtenances.

3.18 SYSTEM – 7 (Continued)

Piping Symbol/Service: CW Domestic Cold Water
PW Potable Water

Buried and Encased Pipe/Valves:

3-inches and smaller	Pipe:	Copper Tube:	Type K with polythelene tape coating. Field application of coating to all couplings. Refer to Section 15105, Copper Pipe.
		Conn:	Solder type, with threaded or flanged adapters for valves.
		Ftgs:	Refer to Section 15105, Copper Pipe.
3-inches and smaller	Valves:	Gate:	Refer to Section 15110, Gate Valves, Operators and Appurtenances, with extension stem and valve box. Coating in accordance with Section 09900, Painting.
4-inches and larger	Pipe:	Ductile Iron:	Class 53 with exterior bituminous coating. Refer to Section 15101, Ductile Iron Pipe.
		Conn:	Mechanical joint. Flanged adapters for valves.
		Ftgs:	Refer to Section 15101, Ductile Iron Pipe: Coating, lining, and ends to match pipe.
4-inches and larger	Valves:	Butterfly:	Same as exposed with extension stem and valve box. Coating in accordance with Section 09900, Painting.

Exposed Pipe/Valves:

3-inches and smaller	Pipe:	Copper Tube:	Type K (rigid). Refer to Section 15105, Copper Pipe and Section 15141, Potable Water Piping System. Insulation in accordance with Section 15082, Insulation of Piping and Equipment - HVAC and Process Air.

3.18 SYSTEM – 7 (Continued)

Piping Symbol/Service: CW Domestic Cold Water
PW Potable Water

		Conn:	Solder type with threaded or flanged adapters for valves. Insulation in accordance with Section 15082, Insulation of Piping and Equipment - HVAC and Process Air.
		Ftgs:	Refer to Section 15105, Copper Pipe. Insulation in accordance with Section 15082, Insulation of Piping and Equipment - HVAC and Process Air.
2-inches and smaller	Valves:	Refer to Section 15141, Potable Water Piping System. Insulation in accordance with Section 15082, Insulation of Piping and Equipment - HVAC and Process Air.	
4-inches and larger	Pipe:	Ductile Iron:	Class 53 with cement mortar lining. Refer to Section 15101, Ductile Iron Pipe. Insulation in accordance with Section 15082, Insulation of Piping and Equipment - HVAC and Process Air.
		Conn:	Grooved mechanical pipe coupling or flanged. Insulation in accordance with Section 15082, Insulation of Piping and Equipment - HVAC and Process Air.
		Ftgs:	Refer to Section 15101, Ductile Iron Pipe, ends and lining to match pipe. Insulation in accordance with Section 15082, Insulation of Piping and Equipment - HVAC and Process Air.
2-1/2-inches and larger	Valves:	Butterfly:	Refer to Section 15111, Butterfly Valves, Operators and Appurtenances. Insulation in accordance with Section 15082, Insulation of Piping and Equipment - HVAC and Process Air.

3.18 SYSTEM – 7 (Continued)

Piping Symbol/Service:		CW PW	Domestic Cold Water Potable Water	
2-1/2-inches and larger (Continued)	Valves:		Swing Check:	Refer to Section 15114, Check Valves and Appurtenances. Insulation in accordance with Section 15082, Insulation of Piping and Equipment - HVAC and Process Air.

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3.20 SYSTEM – 9

Piping Symbol/Service:	CWR	Cooling Water Return
	CWS	Cooling Water Supply
	RW	Reuse Water
	GW	Groundwater

Test Requirements:	Medium:	Water: Refer to Paragraph 3.5.C., above.	
	Pressure:	Refer to Schedule below.	
	Duration:	60 minutes.	
Gasket Requirements:	Flange:	Ductile Iron: Refer to Section 15101, Ductile Iron Pipe. Steel: Refer to Section 15102, Steel Pipe. CPVC: Refer to Section 15106, Thermoplastic Pipe.	
	Push-on/Mech Cpl:	Ductile Iron: Refer to Section 15101, Ductile Iron Pipe.	
Exposed Pipe/Valves:			
3-inches and smaller	Pipe:	Copper Tube:	Type K (rigid). Test to 125 psig. Refer to Section 15105, Copper Pipe.
		Conn:	Solder type with threaded or flanged adapters for valves.
		Ftgs:	Refer to Section 15105, Copper Pipe.
2-inches and smaller	Valves:	Ball:	Refer to Section 15115, Ball Valves, Operators and Appurtenances.
		Globe:	Crane 7TF or 17TF, Lunkenheimer 123 or 214, or equal.
		Swing Check:	Refer to Section 15114, Check Valves and Appurtenances.
4-inches and larger	Pipe:	Ductile Iron:	Class 53 with cement mortar lining. Test to 150 psig. Refer to Section 15101, Ductile Iron Pipe.
		Conn:	Flanged.
		Ftgs:	Refer to Section 15101, Ductile Iron Pipe: Ends and lining to match pipe.
2-1/2-inches and larger	Valves:	Butterfly:	Refer to Section 15111, Butterfly Valves, Operators and Appurtenances.

3.20 SYSTEM – 9 (Continued)

Piping Symbol/Service: CWR Cooling Water Return
CWS Cooling Water Supply
RW Reuse Water
GW Groundwater

2-1/2-inches and larger (Cont'd)	Valves	Eccentric Plug:	Refer to Section 15112, Eccentric Plug Valves, Operators and Appurtenances
		Swing Check:	Refer to Section 15114, Check Valves and Appurtenances.
Buried and Encased Pipe/Valves:			
3-inches and smaller	Pipe:	Copper Tube:	Type K with polyethylene tape coating. Test to 125 psig. Field application of coating to all couplings. Refer to Section 15105, Copper Pipe. Test to 125 psig.
		Conn:	Solder type, with threaded or flanged adapters for valves.
		Ftgs:	Same as exposed.
3-inches and smaller	Valves:	Gate:	Refer to Section 15110, Gate Valves, Operators and Appurtenances, with extension stem and valve box. Coating in accordance with Section 09900, Painting.
4-inches and larger	Pipe:	Ductile Iron:	Same as exposed with bituminous coating. Test to 200 psig.
		Conn:	Mechanical joint. Flanged adapters for valves.
		Ftgs:	Refer to Section 15101, Ductile Iron Pipe: Coating, lining, and ends to match pipe.
4-inches and larger	Valves:	Butterfly:	Same as exposed with extension stem and valve box. Coating in accordance with Section 09900, Painting.

3.20 SYSTEM – 9 (Continued)

Piping Symbol/Service: CWR Cooling Water Return
CWS Cooling Water Supply
RW Reuse Water
GW Groundwater

All sizes	Pipe:	CPVC:	Sch. 80, test to 125 psig. Refer to Section 15106, Thermoplastic Pipe.
		Conn:	Plain end, solvent weld, flanged for valves 3-inches and larger. Flanged or solvent vent for piping in grit basins.
		Ftgs:	Refer to Section 15106, Thermo-plastic Pipe.
All sizes	Valves:	Refer to Section 15113, Thermoplastic Valves, Operators and Appurtenances.	
All sizes	Pipe:	Steel:	Sch. 40 with cement mortar lining for piping in Reuse Water Pump Station. Test to 100 psig. Refer to Section 15102, Steel Pipe.
		Conn:	Butt weld or flanged.
		Ftgs:	Refer to Section 15102, Steel Pipe. Ends and lining to match pipe.
All sizes	Valves:	Butterfly:	Refer to Section 15111, Butterfly Valves, Operators and Appurtenances.
All sizes	Pipe	Polypro-pylene:	Refer to Section 15106, Thermo-plastic Pipe Test. Test to 120 psig.
		Conn:	Refer to Section 15106, Thermo-plastic Pipe.
		Ftgs:	Refer to Section 15106, Thermo-plastic Pipe.
All sizes	Valves	Polypropylene, Refer to Section 15113, Thermoplastic Valves, Operators and Appurtenances	

3.20 SYSTEM – 9 (Continued)

Piping Symbol/Service:

CWR	Cooling Water Return
CWS	Cooling Water Supply
RW	Reuse Water
GW	Groundwater

All sizes	Pipe:	CPVC:	Sch. 80, test to 150 psig. Refer to Section 15106, Thermoplastic Pipe.
		Conn:	Plain end, solvent weld.
		Ftgs:	Refer to Section 15106, Thermoplastic Pipe.
All sizes	Valves:	Refer to Section 15113, Thermoplastic Valves, Operators and Appurtenances.	
All sizes	Pipe:	Steel:	Sch. 80, test to 250 psig. Refer to Section 15102, Steel Pipe.
		Conn:	Plain end, weld.
		Ftgs:	Refer to Section 15102, Steel Pipe.
All sizes	Valves:	N/A	
All sizes	Pipe:	Stainless Steel:	Sch. 40S. Refer to Section 15103, Stainless Steel Pipe.
		Conn:	Butt, weld, threaded adapter for valves.
		Ftgs:	Material, ends and wall thickness to match pipe. Refer to Section 15103, Stainless Steel Pipe.
All sizes	Valves:	N/A	(ADD. NO. 3)

Remarks:
1. Refer to Drawings for pipe size and valve type. Omit coating on encased pipe.
2. Manual air vents shall be provided at the high points and drains provided at the low points of each reach of pipeline as specified in Paragraph 3.7.A.1.a., above.

3.21 SYSTEM - 9A

Piping Symbol/Service: SRW Service Water
NPW Non Potable Water

Test Requirements:	Medium:	Water: Refer to Paragraph 3.5.C., above.	
	Pressure:	125 psig.	
	Duration:	60 minutes.	
Gasket Requirements:	Flange:	Refer to Section 15106, Thermoplastic Pipe.	
	Push-on/Mech Cpl:	N/A.	
Exposed Pipe/Valves:			
3-inches and smaller	Pipe:	CPVC:	Sch. 80. Refer to Section 15106, Thermoplastic Pipe.
		Conn:	Plain end, solvent weld with threaded or flanged adapters for valves.
		Ftgs:	Refer to Section 15106, Thermoplastic Pipe.
3-inches and smaller	Valves:	Refer to Section 15113, Thermoplastic Valves, Operators and Appurtenances.	
Buried and Encased Pipe/Valves:			
3-inches and smaller	Pipe:	CPVC:	Schedule 80, Refer to Section 15106, Thermoplastic Pipe.
		Conn:	Plain end, solvent weld with threaded or flanged adapters for valves.
		Ftgs:	Refer to Section 15106, Thermoplastic Pipe.
3-inches and smaller	Valves:	Refer to Section 15113, Thermoplastic Valves, Operators and Appurtenances.	

Remarks:
1. Refer to Drawings for pipe size and valve types. Omit coating on encased pipe.

3.23 SYSTEM - 11

Piping Symbol/Service: SWR Seal Water

Test Requirements:	Medium:	Water: Refer to Paragraph 3.5.C., above.	
	Pressure:	150 psig.	
	Duration:	120 minutes.	
Gasket Requirements:	Flange:	N/A.	
	Push-on/Mech Cpl:	N/A.	
Exposed Pipe/Valves:			
All sizes	Pipe:	Steel:	Sch. 40, Refer to Section 15102, Steel Pipe.
		Conn:	Taper threaded.
		Ftgs:	Refer to Section 15102, Steel Pipe.
		CPVC:	Sch. 80. Refer to Section 15106, Thermoplastic Pipe.
		Conn:	Plain end, solvent weld, flanged for valves 3-inch and larger.
		Ftgs:	Refer to Section 15106, Thermoplastic Pipe.
All sizes	Valves:	Ball:	Refer to Section 15115, Ball Valves, Operators and Appurtenances.
		Globe:	Crane 7TF or 17TF, Lunkenheimer 123 or 214, or equal.
		Swing Check:	Refer to Section 15114, Check Valves and Appurtenances. Refer to Section 15113, Thermo-plastic Valves, Operators and Appurtenances, for CPVC valves.

Remarks:
1. Refer to Drawings for pipe size and valve types.
2. Note that the pipe support layouts, as shown on the Drawings, are based on Schedule 40 steel pipe.

3.24 SYSTEM - 12

Piping Symbol/Service:	D	Drain
	DW	Dewatering
	ML	Mixed Liquor
	PI	Primary Influent

Test Requirements:	Medium:	Water: Refer to Paragraph 3.5.C., above.
	Pressure:	D: Test Aeration Basin at 50 psig, Secondary Sedimentation Basin at 35 psig, Blower Facility at 125 psig, Other drain lines at 10 psig. ML: Test at 25 psig. TPS: Test at 150 psig.
	Duration:	120 minutes.
Gasket Requirements:	Flange:	Ductile Iron: Refer to Section 15101, Ductile Iron Pipe. Concrete: Refer to Section 15104, Concrete Pipe.
	Push-on/Mech Cpl:	Refer to Section 15101, Ductile Iron Pipe, and Section 15108.1, Centrifugally Cast Fiberglass Reinforced Polymer Mortar Pipe.

Exposed Pipe/Valves:

4-inches and larger	Pipe:	Ductile Iron:	Thickness Class 53. Refer to Section 15101, Ductile Iron Pipe.
		Conn:	Grooved end mechanical pipe coupling, flanged adapters for valves.
		Ftgs:	Refer to Section 15101, Ductile Iron Pipe: Coating, lining and ends to match pipe.
4-inches and larger	Valves:	Eccentric Plug:	Refer to Section 15112, Eccentric Plug Valves, Operators and Appurtenances. Install valve with seat upstream.
		Swing Check:	Refer to Section 15114, Check Valves and Appurtenances.

Buried and Encased Pipe/Valves:

4-inches to 48-inches	Pipe:	Ductile Iron:	Thickness Class 53. Refer to Section 15101, Ductile Iron Pipe.

3.24 SYSTEM – 12 (CONTINUED)

Piping Symbol/Service:	D	Drain
	DW	Dewatering
	ML	Mixed Liquor
	PI	Primary Influent

4-inches to 48-inches (Cont'd)	Pipe:	Conn:	Bell and spigot with O-ring rubber gasket joint for drain lines tested at 10 psi, mechanical joint for others.
		Ftgs:	Refer to Section 15101, Ductile Iron Pipe: Coating, lining and ends to match pipe.
4-inches to 48-inches	Valves:	Same as exposed with extension stem and valve box. Coating in accordance with Section 09900, Painting.	
54-inches and larger	Pipe:	FRP Mortar Pipe:	ASTM D 3262, Refer to Section 15108.1, Centrifugally Cast, Fiberglass Reinforced Polymer Mortar Pipe.
		Conn:	Push-on joint, refer to Section 15108.1, Centrifugally Cast, Fiberglass Reinforced Polymer Mortar Pipe.
		Ftgs:	Refer to Section 15108.1, Centrifugally Cast, Fiberglass Reinforced Polymer Mortar Pipe.
54-inches and larger	Valves:	N/A.	

Remarks:
1. Refer to Drawings for pipe size and valve types. Omit coating on encased pipe.
2. Manual air vents shall be provided at the high points and drains provided at the low points of each reach of pipeline as specified in Paragraph 3.7.A.1.a., above.

3.25 SYSTEM – 12A

Piping Symbol/Service: PD Process Drain

Test Requirements:	Medium:	Water: Refer to Paragraph 3.5.C., above.	
	Pressure:	160 psig.	
	Duration:	120 minutes.	
Gasket Requirements:	Flange:	N/A.	
	Push-on/Mech Cpl:	Refer to Section 15106, Thermoplastic Pipe.	
Exposed Pipe/Valves:			
All sizes	Pipe:	CPVC:	Sch. 80. Refer to Section 15106, Thermoplastic Pipe.
		Conn:	Plain end, solvent weld, flanged for valves 3-inch and larger.
		Ftgs:	Refer to Section 15106, Thermoplastic Pipe.
All sizes	Valves:	Refer to Section 15113, Thermoplastic Valves, Operators and Appurtenances.	
Buried and Encased Pipe/Valves:			
All sizes	Pipe:	CPVC:	SDR-26. Refer to Section 15106, Thermoplastic Pipe.
		Conn:	Bell and spigot.
		Ftgs:	Refer to Section 15106, Thermoplastic Pipe.
All sizes	Valves:	Refer to Section 15113, Thermoplastic Valves, Operators and Appurtenances.	

Use the following for buried and encased piping at the Influent Metering and Sampling Building.

All sizes	Pipe:	Ductile Iron:	Class 53, Test at 15 psig
		Conn:	Mechanical Joint or as shown on the drawings, Refer to Section 15101, Ductile Iron Pipe.
		Ftgs:	Refer to Section 15101, Ductile Iron Pipe.

Piping Symbol/Service: PD Process Drain

All sizes	Valves	Gate:	Refer to Section 15101, Ductile Iron Pipe, Gate Valves, Operators and Appurtenances.

Remarks:
1. Refer to Drawings for pipe size and valve types. Omit coating on encased pipe.
2. Manual air vents shall be provided at the high points and drains provided at the low points of each reach of pipeline as specified in Paragraph 3.7.A.1.a., above.

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3.27 SYSTEM - 13

Piping Symbol/Service:	RW	Raw Wastewater
	FM	Forcemain
	SS	Sanitary Sewer

Test Requirements:	Medium:	Wastewater: Refer to Paragraph 3.5.C., above.	
	Pressure:	350 psig.	
	Duration:	120 minutes.	
Gasket Requirements:	Flange:	Refer to Section 15101, Ductile Iron Pipe.	
	Push-on/Mech Cpl:	Ductile Iron: Refer to Section 15101, Ductile Iron Pipe.	
Exposed Pipe/Valves:			
All sizes	Pipe:	Ductile Iron:	Class 55, epoxy lined interior, Refer to Section 15101, Ductile Iron Pipe.
		Conn:	Flanged.
		Ftgs:	Refer to Section 15101, Ductile Iron Pipe: Coating, lining and ends to match pipe.
All sizes	Valves:	N/A.	
Buried and Encased Pipe/Valves:			
48-inches and smaller	Pipe:	Ductile Iron:	Same as exposed. Refer to Section 15101, Ductile Iron Pipe.
		Conn:	Mechanical joint.
		Ftgs:	Refer to Section 15101, Ductile Iron Pipe: Coating, lining and ends to match pipe.
48-inches and smaller	Valves:	N/A.	

Remarks:
1. Refer to Drawings for pipe size and valve type. Omit coating on encased pipe.
2. Manual air vents shall be provided at the high points and drains provided at the low points of each reach of pipeline as specified in Paragraph 3.7.A.1.a., above.

3.41 SYSTEM - 19

Piping Symbol/Service:	CLS	Chlorine Solution
	HCL	Hydrochloric Acid
	NAOCL	Sodium Hypochlorite
	CAS	Caustic Soda
	VCEN	Centrate Vent
	SPD	Sump Pump Discharge (Area 80 only)

Test Requirements:	Medium:	Water: Refer to Paragraph 3.5.C., above.
	Pressure:	200 psig for piping in trenches and containment areas. 100 psig for other piping. 140 psig for piping between the RW ejector located in the Reuse Water Load Center Building and the RW application point in Area 90.
	Duration:	120 minutes.
Gasket Requirements:	Flange:	N/A.
	Push-on/Mech Cpl:	N/A.

Exposed Pipe/Valves:

All sizes	Pipe:	CPVC:	Sch. 80. Refer to Section 15106, Thermoplastic Pipe.
		Conn:	Plain end, solvent weld, flanged for valves 3-inch and larger.
		Ftgs:	Refer to Section 15106, Thermoplastic Pipe.
All sizes	Valves:	Refer to Section 15113, Thermoplastic Valves, Operators and Appurtenances.	

Buried and Encased Pipe/Valves:

All sizes	Pipe:	CPVC:	Same as exposed.
		Conn:	Same as exposed.
		Ftgs:	Same as exposed.
All sizes	Valves:	Same as exposed with extension stem and valve box.	

Remarks:
1. Refer to Drawings for pipe size and valve type.

3.42 SYSTEM - 20

Piping Symbol/Service: CG Chlorine Gas

Test Requirements:	Medium:	Refer to Paragraph 3.5.D., above.	
	Pressure:	150 psig.	
	Duration:	120 minutes.	
Gasket Requirements:	Flange:	Gylon gasketing, Garlock Style 3500 or 3510.	
	Push-on/Mech Cpl:	N/A.	
Exposed Pipe/Valves:			
All sizes	Pipe:	CPVC:	ASTM D 1784, Class 23447-B, NSF certified, Sch. 80. Pipe and fittings shall be painted. Refer to Section 15106, Thermoplastic Pipe.
		Conn:	Plain end, solvent weld, flanged for valves 3-inch and larger.
		Ftgs:	CPVC, Sch. 80, solvent weld.
4-inches and less	Valves:	Ball:	Refer to Section 15113, Thermoplastic Valves, Operators and Appurtenances, with Teflon seats and EPDM O-rings.
		Diaphragm:	Refer to Section 15113, Thermoplastic Valves, Operators and Appurtenances, with EPDM or Teflon diaphragm.
		Ball Check:	Refer to Section 15113, Thermoplastic Valves, Operators and Appurtenances, with EPDM or Teflon seats/seals.
5-inches and larger	Valves:	Diaphragm:	Refer to Section 15113, Thermoplastic Valves, Operators and Appurtenances

3.44 SYSTEM – 21A

Piping Symbol/Service: FEC Ferric Chloride

Test Requirements:	Medium:	Water: Refer to Paragraph 3.5.C., above.	
	Pressure:	200 for CPVC, 100 psig for DCHDPE.	
	Duration:	120 minutes.	
Gasket Requirements:	Flange:	Refer to Section 15106, Thermoplastic Pipe.	
	Push-on/Mech Cpl:	N/A.	
Exposed Pipe/Valves:			
4-inches and smaller	Pipe:	CPVC:	Sch. 80. Piping and fittings exposed shall be painted. Refer to Section 15106, Thermoplastic Pipe.
		Conn:	Plain end, solvent weld, flanged for valves 3-inch and larger.
		Ftgs:	Refer to Section 15106, Thermoplastic Pipe.
4-inches and smaller	Valves:	Refer to Section 15113, Thermoplastic Valves, Operators and Appurtenances.	
Buried and Encased Pipe/Valves:			
4-inches and smaller	Pipe:	DCHDPE:	Same as exposed. Refer to Section 15109, HDPE Double-Containment Pipe.
		Conn:	Same as exposed.
		Ftgs:	Same as exposed.
4-inches and smaller	Valves:	Same as exposed with extension stem and valve box.	

Remarks:
1. Refer to Drawings for pipe size and valve type. Omit coating on encased pipe.

3.45 SYSTEM - 21B

Piping Symbol/Service: FEC Ferric Chloride (to Influent Junction Structure)

TEST REQUIREMENTS:	Medium:	Water: Refer to Paragraph 3.5.C., above.	
	Pressure:	150 psig.	
	Duration:	120 minutes.	
GASKET REQUIREMENTS:	Flange:	N/A.	
	Push-on/Mech Cpl:	N/A.	

BURIED AND ENCASED PIPE/VALVES:

All sizes	Pipe:	DCFRP:	Sch. 80. Refer to Section 15108, Fiberglass Reinforced Plastic Pipe. Provide magnetic tracer tape.
		Conn:	Plain end, solvent weld, flanged for valves 3-inches and larger.
		Ftgs:	Refer to Section 15108, Fiberglass Reinforced Plastic Pipe.
All sizes	Valves:	Refer to Section 15112 – Eccentric Plug Valves, Operators and Appurtenances; Section 15113 – Thermoplastic Valves Operators and Appurtenances; Section 15114 – Check Valves and Appurtenances; Section 15115 – Ball Valves, Operators and Appurtenances; Section 15119 – Specialty Valves and Appurtenanances.	

Remarks:
1. Refer to Drawings for pipe size and valve type. Omit coating on encased pipe.

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3.48 SYSTEM - 22

Piping Symbol/Service: FA Foul Air
FAD Foul Air Duct

Test Requirements:	Medium:	Air: Refer to Paragraph 3.5.B., above.	
	Pressure:	15 psig.	
	Duration:	60 minutes.	
Gasket Requirements:	Flange:	Gylon gasketing, Garlock style 3504.	
	Push-on/Mech Cpl:	N/A.	
Exposed Pipe/Valves:			
All sizes	Pipe:	FRP:	Refer to Section 13125, Odor Control System Wet Scrubber, and Section 15812, Corrosion Resistant Ductwork and Accessories.
		Conn:	Butt weld or flanged. Refer to Section 15812, Corrosion Resistant Ductwork and Accessories.
		Ftgs:	FRP to match pipe, glass filament wound reinforcing only. Refer to Section 15812, Corrosion Resistant Ductwork and Accessories.
All sizes	Valves:	FRP Dampers:	Refer to Section 15812, Corrosion Resistant Ductwork and Accessories.
Buried and Encased Pipe/Valves:			
All sizes	Pipe:	HDPE:	Refer to Section 13125, Odor Control System Wet Scrubber.
		Conn:	Flanged or plain end butt weld.
		Ftgs:	HDPE to match pipe. Refer to Section 15812, Corrosion Resistant Ductwork and Accessories.
All sizes	Valves:	Butterfly:	Same as exposed with extension stem and valve box. Coating in accordance with Section 09900, Painting.

Remarks:
1. Refer to Drawings for pipe size and valve type. Omit coating on encased pipe.

3.50 SYSTEM - 24

Piping Symbol/Service:	SW	Sanitary Waste
	STDR	Storm Drain
	V	Vent
	RD	Roof Drain
	NSD	Non-Sanitary Drain

Test Requirements:	Medium:	In accordance with Phoenix Plumbing Code.
	Pressure:	In accordance with Phoenix Plumbing Code.
	Duration:	In accordance with Phoenix Plumbing Code.
Gasket Requirements:	Flange:	Compressed gasketing consisting of organic fibers (Kevlar) and neoprene binder.
	Push-on/Mech Cpl:	Nitrile or neoprene.

Exposed Pipe/Valves:

1 1/2-inches and smaller	Pipe:	Steel:	Schedule 80. Refer to Section 15106, Thermoplastic Pipe.
		Conn:	Plain end, solvent weld.
		Ftgs:	Refer to Section 15106, Thermoplastic Pipe.
2-inches thru 12-inches	Pipe:	CISP:	ASTM A 74.
		Conn:	Service hub and spigot compression type or hubless cast iron sanitary system in accordance with CISPI 301.
		Ftgs:	CISP, ASTM A 74, joint options to match pipe.
14-inches and larger	Pipe:	Ductile Iron:	AWWA C151. Refer to Section 15101, Ductile Iron Pipe.
		Conn:	Flanged or mechanical.

3.50 SYSTEM – 24 (CONTINUED)

Piping Symbol/Service:	SW	Sanitary Waste
	STDR	Storm Drain
	V	Vent
	RD	Roof Drain
	NSD	Non-Sanitary Drain

14-inches and larger (Cont'd)	Pipe:	Ftgs:	Refer to Section 15101, Ductile Iron Pipe. Ends to match pipe.

Buried and Encased Pipe/Valves:

12-inches and smaller	Pipe:	CISP:	Same as exposed.
12-inches and smaller	Valves:	N/A.	
14-inches and larger	Pipe:	Ductile Iron:	Same as exposed.
14-inches and larger	Valves:	N/A.	

Buried and Encased Pipe and Valves Beyond 5 Feet Outside Building:

8-inches and smaller	Pipe:	CPVC:	ASTM D 1784, Class 23447-B, ASTM F 441, Sch. 80. Refer to Section 15106, Thermoplastic Pipe.
		Conn:	Plain end, solvent weld.
		Ftgs:	CPVC, socket type, DWV, ASTM F 493.
8-inches and smaller	Valves:	N/A.	
10-inches and 12-inches	Pipe:	CPVC:	ASTM D 3034, SDR 35.
		Conn:	Push-on with nitrile gasket.
		Ftgs:	CPVC or IPS cast iron: Ends to match pipe.
10-inches and 12-inches	Valves:	N/A.	

3.50 SYSTEM – 24 (CONTINUED)

Piping Symbol/Service:	SW	Sanitary Waste
	STDR	Storm Drain
	V	Vent
	RD	Roof Drain
	NSD	Non-Sanitary Drain

14-inches and larger	Pipe:	RCP:	Refer to Section 15104, Concrete Pipe.
		Conn:	ASTM C 443, rubber gasket type.
		Ftgs:	Concrete manhole as shown on the Drawings.
14-inches and larger	Valves:	N/A.	

Remarks:
1. Refer to Drawings for pipe size and valve type. Omit coating on encased pipe.

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3.51 SYSTEM - 25

Piping Symbol/Service:	CD	Chemical Drain
	VC	Chemical Vent

Test Requirements:	Medium:	In accordance with Phoenix Plumbing Code.	
	Pressure:	In accordance with Phoenix Plumbing Code.	
	Duration:	In accordance with Phoenix Plumbing Code.	
Gasket Requirements:	Flange:	N/A.	
	Push-on/Mech Cpl:	N/A.	
Exposed Pipe/Valves:	Refer to Drawings for pipe size and valve type.		
All sizes	Pipe:	PP:	ASTM D 4101, Sch. 40, flame retardant. Refer to Section 15106, Thermoplastic Pipe.
		Conn:	Refer to Section 15106, Thermoplastic Pipe.
		Ftgs:	PP, socket type coil fused DWV. Refer to Section 15106, Thermoplastic Pipe.
All sizes	Valves:	N/A.	
Buried and Encased Pipe/Valves:			
All sizes	Pipe:	PP:	Same as exposed. Provide magnetic tracer tape.
		Conn:	Refer to Section 15106, Thermoplastic Pipe.
		Ftgs:	Same as exposed.
All sizes	Valves:	N/A.	

Remarks:
1. Refer to Drawings for pipe size and valve type. Omit coating on encased pipe.

3.60 SYSTEM - 32

Piping Symbol/Service: OCD Odor Control Drain
SBD Scrubber Blow Down

Test Requirements:	Medium:	Water: Refer to Paragraph 3.5.C., above.	
	Pressure:	OCD test at 25 psig, SBD test at 100 psig.	
	Duration:	120 minutes.	
Gasket Requirements:	Flange:	N/A.	
	Push-on/Mech Cpl:	N/A.	
Exposed Pipe/Valves:			
All sizes	Pipe:	CPVC:	Sch. 80. Refer to Section 15106, Thermoplastic Pipe.
		Conn:	Plain end, solvent weld.
		Ftgs:	Refer to Section 15106, Thermoplastic Pipe.
All sizes	Valves:	Refer to Section 15113, Thermoplastic Valves, Operators and Appurtenances.	
Buried and Encased Pipe/Valves:			
All sizes	Pipe:	CPVC:	Sch. 80. Refer to Section 15106, Thermoplastic Pipe.
		Conn:	Plain end, solvent weld same as exposed.
		Ftgs:	Refer to Section 15106, Thermoplastic Pipe.
All sizes	Valves:	N/A.	

Remarks:
1. Refer to Drawings for pipe size and valve type. Omit coating on encased pipe.

3.63 SYSTEM - 33

Piping Symbol/Service: POL Polymer
DP Diluted Polymer

Test Requirements:	Medium:	Water: Refer to Paragraph 3.5.C., above.	
	Pressure:	200 psig for piping in trenches. 150 psig for others.	
	Duration:	120 minutes.	
Gasket Requirements:	Flange:	Refer to Section 15106, Thermoplastic Pipe.	
	Push-on/Mech Cpl:	N/A.	
Exposed Pipe/Valves:			
8-inches and smaller	Pipe:	CPVC:	Sch. 80. Refer to Section 15106, Thermoplastic Pipe.
		Conn:	Plain end, solvent weld.
		Ftgs:	Refer to Section 15106, Thermoplastic Pipe.
8-inches and smaller	Valves:	Refer to Section 15113, Thermoplastic Valves, Operators and Appurtenances.	
Buried and Encased Pipe/Valves:			
3-inches and smaller	Pipe:	CPVC:	Sch. 80. Refer to Section 15106, Thermoplastic Pipe.
		Conn:	Plain end, solvent weld.
		Ftgs:	Refer to Section 15106, Thermoplastic Pipe.
3-inches and smaller	Valves:	Refer to Section 15113, Thermoplastic Valves, Operators and Appurtenances, with extension stem and valve box.	

Remarks:
1. Refer to Drawings for pipe size and valve type. Omit coating on encased pipe.

+ + END OF SECTION + +

SECTION 15051

BURIED PIPING INSTALLATION

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to perform all excavating, backfilling, filling, grading and disposing of earth materials and to furnish, install and test all buried piping, fittings, and specials. The Work includes, but is not limited to, the following:
      a. Excavation and backfill.
      b. All temporary means required to prevent discharge of sediment to water courses from dewatering systems or erosion.
      c. All types and sizes of buried piping, except those specified under other Sections.
      d. Piping beneath structures.
      e. Restraints and thrust blocks.
      f. Pipe encasements.
      g. Work on or affecting existing piping.
      h. Testing.
      i. Cleaning and disinfecting.
      j. Installation of all jointing and gasketing materials, specials, flexible couplings, mechanical couplings, harnessed and flanged adapters, sleeves, tie rods, and all other Work required to complete the buried piping installation.
      k. Incorporation of valves, meters and special items shown on the Drawings or specified into the piping systems as required and as specified in the appropriate Division 15, Mechanical, Sections.
      l. Unless otherwise specifically shown on the Drawings, specified, or included under other Sections, all buried piping Work required, beginning at the outside face of structures or structure foundations and extending away from structure.
   2. No classification of excavated materials will be made. Excavation includes all materials regardless of type, character, composition, moisture, or condition thereof.

B. Coordination:
   1. Review installation procedures under other Sections and coordinate with the Work that is related to this Section.
   2. Section 15051, Buried Piping Installation, specifies the installation of all buried piping materials specified in Sections of Division 15, Mechanical. Coordinate with all applicable Sections.

1.2 QUALITY ASSURANCE

A. Conform to all requirements of Section 601 of the Uniform Standard Specifications for Public Work Construction by the Maricopa Association of Governments (MAG), as supplemented by the City of Phoenix. If there is a conflict between MAG Standard Specifications and these Specifications, the Provisions of these Specifications shall govern.

B. Testing Services:
   1. General: Testing of materials, testing for moisture content during placement and compaction of fill materials, and of compaction requirements for compliance with technical requirements of the Specifications shall be performed by a testing laboratory as designated in Section 01451, Testing Laboratory Services Furnished by OWNER, and Section 01452, Testing Laboratory Services Furnished by CONTRACTOR.
   2. OWNER'S Testing Agency Scope:
      a. Test CONTRACTOR'S proposed materials in the laboratory and/or field for compliance with the Specifications.
      b. Perform field moisture content and density tests to assure that the specified compaction of backfill materials has been obtained.
      c. Report all test results to the ENGINEER and CONTRACTOR.
   3. Authority and Duties of OWNER'S Testing Agency: Technicians representing the testing laboratory shall inspect the materials in the field and perform tests and shall report their findings to the ENGINEER and CONTRACTOR. When the materials furnished or Work performed fails to fulfill Specification requirements, the technician will direct the attention of the ENGINEER and CONTRACTOR to such failure.
      a. The technician shall not act as foreman or perform other duties for CONTRACTOR. Work will be checked as it progresses, but failure to detect any defective Work or materials shall not in any way prevent later rejection when such defect is not discovered, nor shall it obligate the ENGINEER for final acceptance. Technicians are not authorized to revoke, alter, relax, enlarge, or release any requirements of the Contract Documents, nor to approve or accept any portion of the Work.
   4. Responsibilities and Duties of CONTRACTOR:
      a. The use of testing services shall in no way relieve CONTRACTOR of the responsibility to furnish materials and construction in full compliance with the Contract Documents.
      b. To facilitate testing services:
         1) Secure and deliver to the ENGINEER or to the testing agency, without cost, preliminary representative samples of the materials he proposes to use and which are required to be tested.
         2) Furnish such casual labor as is necessary to obtain and handle samples at the Work site or at other sources of material.

3) Advise the OWNER'S testing agency sufficiently in advance of operations to allow for completion of quality tests and for the assignment of personnel.

c. CONTRACTOR'S Testing Service shall inspect and approve subgrades and fill layers before further construction Work is performed thereon.

d. Responsibility belongs to CONTRACTOR to accomplish the specified compaction for backfill and to control the operations by confirmation tests to verify and confirm compliance, and is complying at all times, with the requirements of these Specifications concerning compaction, control, and testing.

e. The frequency of CONTRACTOR'S confirmation tests shall be not less than as follows; each test location for trenches shall include tests for each layer, type, or class of backfill from bedding to finish grade.
   1) Trenches for buried pipe:
      a) In open fields: 4 locations every 1,000 linear feet.
      b) Along dirt or gravel roads or off traveled right-of-way: 1 locations every 500 linear feet.
      c) Crossing paved roads: 1 locations along each crossing.
      d) Under pavement cuts or within two feet of pavement edges: 1 location every 400 linear feet.

f. Copies of the test reports shall be submitted promptly to the ENGINEER. CONTRACTOR'S tests shall be performed by a soils testing laboratory acceptable to the ENGINEER.

g. Demonstrate the adequacy of compaction equipment and procedures before exceeding any of the following amounts of earthwork quantities:
   1) 200 linear feet of trench backfill.

h. Until the specified degree of compaction on the previously specified amounts of earthwork is achieved, no additional earthwork of the same kind shall be performed.

i. Periodic compliance tests will be made by the ENGINEER to verify that compaction is conforming to the requirements previously specified, at no cost to CONTRACTOR. Remove the overburden above the level at which the ENGINEER wishes to test and shall backfill and recompact the excavation after the test is complete.

j. If compaction fails to conform to the specified requirements, remove and replace the backfill at proper density or shall bring the density up to specified level by other means acceptable to the ENGINEER. Subsequent tests required to confirm and verify that the reconstructed backfill has been brought up to specified density shall be paid by CONTRACTOR. CONTRACTOR'S confirmation tests shall be performed in a manner acceptable to the ENGINEER. Frequency of confirmation tests for remedial Work shall be double that amount specified for initial confirmation tests.

C. Requirements of Regulatory Agencies:
   1. Comply with requirements of NFPA Standard No. 24 for "Outside Protection" where applicable to water pipe systems used for fire protection.
   2. Comply with requirements of UL, FM and other jurisdictional authorities, where applicable.
   3. Refer to the General and Supplementary Conditions regarding permit requirements for this Project.
   4. Comply with requirements of Phoenix Building Code.
   5. Obtain all necessary permits for Work in roads, rights-of-way, railroads, etc. Also, obtain permits as required by local, state and federal agencies for discharging water from excavations.
   6. Perform excavation Work in compliance with applicable requirements of governing authorities having jurisdiction.

D. Reference Standards: Comply with applicable provisions and recommendations of the following, except as otherwise shown or specified.
   1. Excavation and Backfill:
      a. ASTM D 422, Standard Test Method for Particle-Size Analysis of Soils.
      b. ASTM D 427, Test Method for Shrinkage Factors of Soils by the Mercury Method.
      c. ASTM D 698, Standard Test Method for Laboratory Compaction Characteristics of Soil.
      d. ASTM D 1556, Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.
      e. ASTM D 2166, Standard Test Method for Unconfined Compression Strength of Cohesive Soil.
      f. ASTM D 2922, Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
      g. ASTM D 3017, Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).
      h. ASTM D 4318, Method of Test for Liquid Limit of Soils.
      i. AISC Specifications for the Design, Fabrication, and Erection of Structural Steel for Buildings.
      j. OSHA Standard, Title 29, Code of Federal Regulations, Part 1926, Section .650 (Subpart P - Excavations).
      k. AASHTO T-99, The Moisture-Density Relations of Soils Using a (2.5 kg) 5.5 lb Rammer and a (305 mm) 12 in. Drop {Proctor}
      l. ASSHTO-T-191, Density of Soil in Place by the Sand Cone Method.
      m. Uniform Standard Specifications for Public Work Construction by the Maricopa Association of Governments (MAG), as supplemented by the City of Phoenix, Section 601.
   2. Piping Materials and Installation:
      a. ASTM D 2321, Practice for Underground Installation of Flexible Thermoplastic Pipe.
      b. ASTM D 2774, Practice for Underground Installation of Thermoplastic Pressure Piping.

c. AWWA C105, Polyethylene Encasement for Ductile-Iron Piping for Water and Other Liquids.
d. AWWA C111, Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
e. AWWA C206, Field Welding of Steel Water Pipe.
f. AWWA C600, Installation of Ductile-Iron Water Mains and Their Appurtenances.
g. AWWA C606, Grooved and Shouldered Joints.
h. AWWA C651, Disinfecting Water Mains.
i. AWWA M9, Concrete Pressure Pipe.
j. AWWA M11, Steel Pipe - A Guide for Design and Installation.
k. AWWA M23, PVC - Design and Installation.
l. ASCE MOP No. 37, Design and Construction of Sanitary and Storm Sewers.
m. Concrete Pipe Handbook, American Concrete Pipe Association.
n. NFPA 24, Private Fire Service Mains and Their Appurtenances.
o. NFPA 54, National Fuel Gas Code.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
1. Excavation and Backfill Submittals:
a. Excavation Plan: Prior to start of excavation operations, a written plan shall be submitted to demonstrate compliance with OSHA Standard 29 CFR Part 1926.650. As a minimum, excavation plan shall include:
1) Name of competent person.
2) Excavation method(s) or protective system(s) to be used.
3) Copies of "manufacturer's data" or other tabulated data if protective system(s) are designed on the basis of such data.
b. Excavation and backfill requirements detailing sheeting and bracing, or other protective system(s), dewatering systems, cofferdams, and under-pinning.
c. Shop Drawings shall be prepared by a Registered Professional Engineer, licensed in the State of Arizona, recognized as an expert in the specialty involved. Drawings shall be submitted to ENGINEER for record purposes only. Calculations shall not be submitted. Drawing submittals will not be checked and will not imply approval by ENGINEER of the Work involved. Responsibility belongs to CONTRACTOR for designing, installing, operating and maintaining whatever system is necessary to satisfactorily accomplish all necessary sheeting, bracing, protection, underpinning and dewatering.
d. Samples of all materials, including select backfill, general backfill, granular embedment, crushed stone and sand shall be submitted to the ENGINEER and the testing service. Samples of the proposed material shall be submitted at least 14 days in advance of its anticipated use.

2. Piping Materials and Installation Submittals:
   a. Laying schedules for all piping
   b. Full details of piping, specials, manholes, joints, harnessing and thrust blocks, and connections to existing piping, structures, equipment and appurtenances.
   c. Certificates of compliance with referenced Standards for proposed pipe material.
   d. Descriptions of proposed pipe testing methods, procedures and apparatus. Prepare and submit a report for each test conducted.
3. Field Test Reports:
   a. Testing laboratory shall submit copies of test reports for Field Density of Backfill directly to ENGINEER, with copy to CONTRACTOR
4. Record Drawings:
   a. During progress of the Work, keep an up-to-date set of Record Drawings showing field and Shop Drawing modifications.
   b. Submit Record Drawings prior to the time of Substantial Completion.

1.4 JOB CONDITIONS

A. Subsurface Information: Refer to Section 00700, General Conditions, and Section 00800, Supplementary Conditions, for available data on subsurface conditions. The data is not intended as a representation or warranty of continuity of conditions between soil borings nor of groundwater levels at dates and times other than date and time when measured. OWNER will not be responsible for interpretations or conclusions drawn there from by CONTRACTOR. Data is solely made available for the convenience of CONTRACTOR.
   1. Additional test borings and other exploratory operations may be made by CONTRACTOR, at no additional cost to OWNER.

B. Existing Structures: The Drawings show certain surface and underground structures adjacent to the Work. This information has been obtained from existing records. It is not guaranteed to be correct or complete and is shown on the Drawings for the convenience of CONTRACTOR. Explore ahead of the required excavation to determine the exact location of all existing structures. Structures shall be supported and protected from damage by CONTRACTOR. If they are broken or damaged, restore them immediately at no additional cost to the OWNER.

C. Existing Utilities: Locate existing underground utilities in the areas of the Work. If utilities are to remain in place, provide adequate means of protection during all operations.
   1. Should uncharted or incorrectly charted piping or other utilities be encountered during excavation, consult piping or utility owner and ENGINEER immediately for directions as to procedure. Cooperate with OWNER and utility owner in keeping services and facilities in operation. Repair damaged utilities to satisfaction of utility owner. Comply with requirements of Section 01143, Coordination with OWNER'S Operations.

2. In general, service lines to individual houses and businesses are not shown on the Drawings, however, assume that a service exists for each utility to each house or business.
3. Do not interrupt existing utilities serving facilities occupied and used by OWNER or others, except when permitted in writing by ENGINEER and then only after acceptable temporary utility services have been provided.
4. Demolish and completely remove from site existing underground utilities indicated to be removed. Coordinate with utility companies for shut-off of services if lines are active.

D. Use of Explosives:
1. The use of explosives will not be permitted. Comply with requirements of Section 02220, Demolitions.
1. Do not bring explosives onto site or use in the Work without prior written permission from authorities having jurisdiction. Provide copy of authorization to ENGINEER. Sole responsibility for handling, storage and use of explosive materials, when their use is permitted, belongs to CONTRACTOR.

E. Protection of Persons and Property: Barricade open excavations occurring as part of the Work and post with warning lights. Operate warning lights during hours from dusk to dawn each day and as otherwise required.
1. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout and other hazards created by earthwork operations.

F. Dust Control: Conduct all operations meeting the requirements specified in Section 01414, Earthmoving and Dust Control.

G. Roadways and Walks: Unless otherwise approved by ENGINEER, excavated material and materials of construction shall be so deposited, and the Work shall be so conducted, as to leave open and free for pedestrian traffic all crosswalks, and for vehicular traffic a roadway not less than ten feet in width. All hydrants, valves, fire alarm boxes, letter boxes, and other facilities which may require access during construction shall be kept accessible for use. During the progress of the Work, maintain such crosswalks, sidewalks, and roadways in satisfactory condition and the Work shall at all times be so conducted as to cause a minimum of inconvenience to public travel, and to permit safe and convenient access to private and public property along the line of the Work.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Deliver materials to the site to ensure uninterrupted progress of the Work.

B. Handle all pipe, fittings, specials and accessories carefully with approved handling devices. Do not drop or roll material off trucks. Do not otherwise drop, roll or skid piping.

C. Store pipes and fittings on heavy wood blocking or platforms so they are not in contact with the ground.

D. Unload pipe, fittings and specials opposite to or as close to the place where they are to be installed as is practical to avoid unnecessary handling. Keep pipe interiors completely free from dirt and foreign matter.

E. Inspect delivered pipe for cracked, gouged, chipped, dented or otherwise damaged material and immediately remove from site.

PART 2 - PRODUCTS

2.1 EMBEDMENT AND BACKFILL MATERIALS

A. Pipe Bedding/Granular Embedment:
1. Bedding is the material placed in the area from the bottom of the trench to one foot above the top of the pipe. Pipe bedding shall be Select Material Type B or Aggregate Base Course having the following gradation. Open graded rock will not be used without the written approval of the ENGINEER.

Sieve Sizes (Square Opening)	Percentage by Weight Passing Sieve	
	Select Material Type B	Aggregate Base Course
1-1/2-inch	100	
1-1/4-inch		100
No. 4	30 – 70	38 - 65
No. 8	20 – 60	25 – 60
No. 30	10 – 40	10 – 40
No. 200	0 - 12	3 - 12

2. Unless otherwise noted, the Plasticity Index as tested in accordance with AASHTO T-146, T-89 and T-90 shall not be more than five.

B. Sand:
1. Sand for use as embedment material around plastic pipes (CPVC, FRP Duct, and HDPE Duct) shall consist of natural or manufactured granular material.
2. No sand will be allowed for embedment material around centrifugally cast, fiberglass reinforced polymer mortar pipe.
3. Sand material shall contain no organic material. Sand shall be nonplastic, when tested in accordance with ASTM D 698, 100 percent shall pass a 1/2-inch screen and no more than 20 percent shall pass a No. 200 screen.
4. All material for sand must be tested and approved by the ENGINEER.
5. No sand shall be placed without the approval of the ENGINEER.

C. Encasement Material:
   1. Pipe encasement material shall be Type 2 Portland cement concrete as specified in Section 03300, Cast-In-Place Concrete, unless otherwise shown on the Drawings.

D. Backfill Material:
   1. Materials acceptable for use as backfill above the pipe embedment shall be:
      a. Stockpiled native sandy clay or granular soils obtained from on-site excavations and which are uniformly mixed, contain no organic matter, nor contain rocks or fragments greater than 3-inches in size, nor have greater than 40 percent passing the 200 sieve. The maximum expansion of on-site materials shall be 1.5 percent as performed on a sample remolded to approximately 95 percent of the maximum dry density as determined in accordance with ASTM D 698 at two percent below optimum moisture content under a 100 pound per square foot (psf) surcharge pressure.
      b. Materials from off-site sources shall consist of silty or clayey sand soils which are uniformly mixed, contain no organic matter and which have a Plasticity Index less than ten. The maximum particle size of imported soils shall be 3-inches or less, if required to satisfy trenching, landscaping, or other requirements. The maximum expansion of off-site materials shall be 1.5 percent as performed on a sample remolded to approximately 95 percent of the maximum dry density as determined in accordance with ASTM D 698 at two percent below optimum moisture content under a 100 psf surcharge pressure.
      c. All materials for use as backfill material shall be tested by the laboratory and approved by the ENGINEER.
      d. If on-site material is unsuitable as determined by the ENGINEER, select backfill or approved off-site fill shall be used.

2.2 PIPING MATERIALS

A. Unless otherwise specified, piping materials, including pipe, gaskets, fittings, connection and joint assemblies, linings and coatings, shall be selected from those listed in Section 15050, Piping Systems. Piping materials shall conform to detailed Specifications for each type of pipe and piping appurtenances specified in the applicable Sections of Division 15, Mechanical.

2.3 PIPING IDENTIFICATION

A. Plastic Tracer Tape and Magnetic Tracer Tape Marking shall conform to the requirements specified in Section 15050, Piping Systems.

PART 3 – EXECUTION

3.1 EXCAVATION

A. Provide ENGINEER with sufficient notice and with means to examine the areas and conditions under which excavation is to be performed. ENGINEER will notify CONTRACTOR if conditions are found that may be detrimental to the proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions have been corrected in an acceptable manner.

B. Perform all excavation required to complete the Work as shown on the Drawings, specified and required. Excavations shall include earth, sand, clay, gravel, hardpan, boulders not requiring drilling and blasting for removal, decomposed rock, pavements, rubbish and all other materials within the excavation limits.

C. Excavations for pipelines shall be open excavations. Provide excavation protection system(s) required by ordinances, codes, law and regulations to prevent injury to workmen and to prevent damage to new and existing structures or pipelines. Unless shown on the Drawings or specified otherwise, protection system(s) shall be utilized under the following conditions.
   1. Excavation Less Than Five Feet Deep: Excavations in stable rock or in soil conditions where there is no potential for a cave-in may be made with vertical sides. Under all other conditions, excavations shall be sloped and benched, shielded, or shored and braced.
   2. Excavations More Than Five Feet Deep: Excavations in stable rock where there is no potential for a cave-in may be made with vertical sides. Under all other conditions, excavations shall be sloped and benched, shielded or shored and braced.
   3. Excavation protection system(s) shall be installed and maintained in accordance with drawings submitted under Article 1.3, above.

D. Where the pipeline is to be placed below the ground water table, well points, cofferdams or other acceptable methods shall be used to permit construction of said pipeline under dry conditions. Dry conditions shall prevail until the pipelines are properly jointed, tested and backfilled. Water level shall be maintained below top of backfill at all times.

E. Pumping of water from excavations shall be done in such a manner to prevent the carrying away of unsolidified concrete materials, and to prevent damage to the existing subgrade.

F. Except where otherwise noted on the Drawings, or approved, in writing, by the ENGINEER, no more than 100 feet of trench may be opened in advance of pipe laying.

G. Material Storage: Stockpile satisfactory excavated materials in approved areas, until required for backfill or fill. Place, grade and shape stockpiles for proper drainage.
   1. Locate and retain soil materials away from edge of excavations.
   2. Dispose of excess soil material and waste materials as specified hereinafter.

3. Stockpiled excavated soils for use as subsequent fill shall be classified by laboratory as on-site granular or sandy clay soils. Use and placement of fill shall be performed as specified for each class.
4. Excess soil from excavations shall be disposed of off-site. Disposal shall be in accordance with state and local regulatory requirements

H. Trench width shall be minimized to greatest extent practical but shall conform to the following:
1. Sufficient to provide room for installing, jointing and inspecting piping. Trenches for other than cast-in-place concrete pipe shall conform to the dimensions listed below, unless otherwise shown on the Drawings, and/or approved by the ENGINEER.

Size of Pipe (I.D.) (Inches)	Maximum Width at Top of Pipe Greater than O.D. of Barrel	Minimum Width at Springline Each Side of Pipe
Less than 18	16-inches	6-inches
18 to 24 inclusive	19-inches	8-inches
27 to 39 inclusive	22-inches	9-inches
42 to 60 inclusive	1/2 of Pipe O.D.	12-inches
Over 60	36-inches	12-inches

2. The width of the trench shall not be greater than the maximum indicated above, at and below the level of the top of the pipe. If the maximum width as specified above is exceeded at the top of the pipe, provide, at no additional cost to the OWNER, the necessary loading bearing capacity by means of bedding, having a higher bedding factor that that specified, higher strength pipe a concrete cradle, cap or encasement, or by other means approved in writing by the ENGINEER.
3. The width of the trench above that level may be made as wide as necessary for shoring or other wall support measures necessary for a safe and proper installation. Trench walls may be sloped in-lieu of shoring, sheeting or other wall support measures. In all cases, responsibility belongs to CONTRACTOR for all costs incurred as a result of increased trench width.
4. Enlargements at pipe joints may be made if required and approved by ENGINEER.
5. Sufficient for shoring and bracing, or shielding and dewatering.
6. Sufficient to allow thorough compaction of embedment material adjacent to bottom half of pipe.

I. Depth of trench shall be as required to install the piping at the elevations shown on the Drawings. For all pipe 12-inches or greater in diameter, excavate for and provide an initial granular bedding at least 4-inches thick or 1/2 the outside diameter of the pipe whichever is greater. The bedding material shall be placed at a uniform density with a minimum compaction density of 95 percent as determined by AASHTOT -99 and T-191 or ASTM D-2922 and D-3017. If required and approved by ENGINEER,

depths may be revised. Remove all loose and unsuitable material from the trench bottom.

J. Subgrades for trench bottoms shall be firm, dense, and thoroughly compacted and consolidated; shall be free from mud, muck, and other soft or unsuitable materials; and shall remain firm and intact under all construction operations. Where ENGINEER considers the existing subgrades unsuitable, remove same and replace it with granular embedment material. Subgrades which are otherwise solid, but which become soft or mucky on top due to construction operations, shall be reinforced with granular embedment material. The finished elevation of stabilized subgrades shall not be above subgrade elevations required for the piping installation as herein specified. Proof roll all subgrades prior to placing of select fill and general fill material.

K. Except at locations where excavation of rock from the bottom of the trench is required, care shall be taken not to excavate below the required depth. Unauthorized excavation below the specified grade line shall be refilled at CONTRACTOR'S expense with aggregate base material compacted to a uniform density of not less than 95 percent of the maximum density as determined by AASHTO T-99 and T-191 or ASTM D-2922 and D-3017. When AASHTOT-99, Method A or B, and T-191 are used for density determination, MAG, Detail 190, will be used for rock correction.

L. Whenever rock is encountered in the trench bottom, it shall be over excavated to a minimum depth of 6-inches below the O.D. of the pipe. This over excavation shall be filled with granular embedment material and compacted to a uniform density of not less than 95 percent of the maximum density as determined by AASHTOT-99 and T-191 or ASTM D-2922 and D-3017.

M. Where pipe is laid in rock excavation, crushed stone as specified in Section 02318, Crushed Stone and Gravel, shall be carefully placed and tamped over the rock before the pipe is laid. Depth of crushed stone shall be at least 6-inches for pipe 16-inches and smaller and 9-inches for pipe 18-inches and larger. After laying pipe, the balance of the embedment and backfill shall be placed as described herein.

3.2 EXCAVATION DRAINAGE AND DEWATERING

A. General:
   1. Prevent surface and subsurface water from flowing into excavations and from flooding adjacent areas.
   2. Remove water from excavations as fast as it collects.
   3. Maintain the ground water level at approximately three feet below the bottom of the excavation to provide a stable surface for construction operations, a stable subgrade for permanent work and to prevent damage to Work during all stages of construction.
   4. Provide and maintain pumps, sumps, suction and discharge lines and other dewatering system components necessary to convey water away from

excavations. Adequate operational standby equipment shall be maintained on the site.

5. Provide approved sediment traps when water is conveyed into water courses.
6. Obtain ENGINEER'S approval before shutting down dewatering system for any reason.

B. Standby Requirements for Dewatering:
   1. Provide standby equipment to ensure continuity of dewatering operations.

C. Disposal of Water Removed by Dewatering System:
   1. Dispose of all water removed from the excavation in such a manner as not to endanger public health, property, or any portion of the Work under construction or completed.
   2. Dispose of water in such a manner as to cause no inconvenience to OWNER, ENGINEER or others involved in work about the site.
   3. Convey water from the excavation in a closed conduit. Do not use trench excavations as temporary drainage ditches.

3.3 PIPE BEDDING/GRANULAR EMBEDMENT

A. Bedding/Granular Embedment shall be placed in the trench from the bottom of the trench to one foot above the top of the pipe.

B. Sand shall be placed as an envelope around CPVC pipes, FRP ducts and all pipe 2-inches and smaller. Place and compact minimum 6-inches of sand all around pipes, in 6-inch lifts, to level 12-inches above the top of pipe. The backfill shall be compacted to not less than 95 percent of laboratory maximum density as determined by AASHTOT-99 and T-191.

C. Carefully place and thoroughly compact all pipe bedding with hand held pneumatic compactors as construction progresses.

D. Granular embedment shall be spread and the surface graded to provide a uniform and continuous support beneath the pipe at all points between bell holes or pipe joints. It will be permissible to slightly disturb the finished subgrade surface by withdrawal of pipe slings or other lifting tackle. After each pipe has been graded, aligned, placed in final position on the bedding material and shoved home, sufficient pipe embedment material shall be deposited and compacted under and around each side of the pipe and back of the bell or end thereof to hold the pipe in proper position and to maintain alignment during subsequent pipe jointing and embedment operations. Embedment material shall be deposited and compacted uniformly and simultaneously on each side of the pipe to prevent lateral displacement.

3.4 PIPE INSTALLATION

A. General:
1. All bedding shall be inspected by ENGINEER prior to laying pipe. Notify ENGINEER in advance of excavating, bedding and pipe laying operations.
2. The ENGINEER prior to installation shall inspect all piping. ENGINEER'S inspection will not relieve CONTRACTOR or manufacturer from responsibility for damaged products.
3. All piping shall be carefully examined for cracks, damage or other defects before installation. Any piping that is defective, including but not limited to, cracked, damaged, in poor condition, or with damaged linings or improper markings shall be rejected, unless the product can be repaired in a manner acceptable to the manufacturer and ENGINEER. Any piping found to be broken or defective after it has been installed shall be removed, replaced or repaired at CONTRACTOR'S expense.
4. Take field measurements, where required, prior to installation to ensure proper fitting of the Work. Uncover existing pipelines sufficiently in advance of the proposed Work in order that the type and location of the existing pipes and joints and other information required to fabricate the proposed piping can be determined. Responsibility to obtain whatever information is required to complete the connections of the proposed pipelines to the existing pipelines belongs to CONTRACTOR.
5. Present all conflicts between piping systems and equipment, structures or facilities to ENGINEER for determination of corrective measures before proceeding.
6. Request instructions from ENGINEER before proceeding if there is a conflict between the manufacturer's recommendations and the Contract Documents.
7. Installation of all pipe, fittings, valves, specials and appurtenances shall be subject to the review and approval of the ENGINEER.
8. Install piping as shown on the Drawings, specified and as recommended by the manufacturer and in conformance with referenced standards and approved Shop Drawings.
9. No pipe shall be brought into position until the preceding length has been bedded and secured in its final position.
10. Minimum earth cover over the piping shall be as shown on the Drawings, specified or directed by the ENGINEER, but in no case shall the earth cover be less than 24 inches for all piping, except drains.
11. Interior of all piping and mating surfaces shall be inspected and all dirt, gravel, sand, debris or other foreign material shall be completely removed from the interior and mating surfaces before installation. Measures shall be taken to maintain the interior of all piping clean until acceptance of the completed Work. Care shall be taken to prevent foreign matter from entering joint space. Bell and spigot mating surfaces shall be wiped clean immediately before piping is laid. For ductile-iron pipe, the bell and spigot mating surfaces shall be thoroughly cleaned with a wire brush.

12. Install piping accurately to line and grade shown on the Drawings, specified or directed, unless otherwise approved by the ENGINEER. Accurate means of determining and checking the alignment and grade shall be used, which shall be subject to the approval of the ENGINEER. Any modifications to the Contract Documents to suit the pipe manufacturer's standard shall be approved by the ENGINEER. Remove and relay piping that is incorrectly installed, at CONTRACTOR'S expense.
13. Do not lay piping in water, unless otherwise specified in these Specifications or approved by the ENGINEER. Ensure that the water level in the trench is at least 6-inches below the bottom of piping. Maintain a dry trench until jointing and backfilling are complete, unless otherwise specified in these Specifications or approved by the ENGINEER.
14. Where unforeseen conditions will not permit the installation of piping as shown on the Drawings or specified, no piping shall be installed without approval of the ENGINEER. Do not modify structures or facilities without approval of the ENGINEER.
15. Start laying piping at lowest point and proceed toward the higher elevations, unless otherwise approved by the ENGINEER. Slope piping uniformly between elevations shown on the Drawings or as otherwise directed by the ENGINEER.
16. Place bell and spigot piping so that the bells face the direction of laying, unless otherwise approved by the ENGINEER.
17. Piping shall be installed so that the barrel of the piping, and not the joints, receives the bearing pressure from the trench bottom or other bedding condition.
18. No piping shall be brought into position until the preceding length, valve, fitting, or special has been bedded and secured in place.
19. Whenever pipe laying is not actively in progress, the open ends of the piping shall be closed by a temporary plug or cap to prevent soil, water and other foreign matter from entering the piping.
20. Field cutting of metallic piping, where required for inserting valves, fitting, specials, and closures, shall be made with a machine specially designed for cutting piping and in accordance with the manufacturer's instructions. Cuts shall be carefully done, without damage to piping, so as to leave a smooth end at right angles to the axis of the piping. Cut end shall be tapered and sharp edges filed off smooth. Flame cutting shall not be permitted. Any piping damaged by CONTRACTOR due to improper or careless methods of cutting shall be replaced or repaired at his expense.
21. Blocking under piping shall not be permitted, unless specifically approved by ENGINEER for special conditions.
22. Protective linings and coatings shall be touched up prior to installation, where required.
23. Except where bends, wyes or similar fittings are used, changes in alignment and grade of the piping shall be made by deflecting joints or with beveled pipe. Permissible joint deflection shall not exceed 75 percent of the amount allowed by the manufacturer.
24. All joints shall be made in the presence of the ENGINEER or his duly authorized representative, except as otherwise approved.

25. Special care shall be taken to ensure that each section of piping abuts against the next in such a manner that there will be not shoulder or unevenness of any kind along the piping invert.
26. Piping shall be rotated as required to place outlets in proper position.
27. Blind flanges and cleanouts shall be provided at locations shown on the Drawings, specified or required. Cleanouts on buried piping shall include all pipe, fittings and appurtenances required to bring cleanout to finished grade and terminate in a flange and blind flange or suitably capped piping as shown on the Drawings. Cleanout piping shall be same as that specified for the main run.
28. All gravity lines shall pitch uniformly at the grade shown on the Drawings or as specified or approved by the ENGINEER.
29. Short pipe stubs, maximum 4-feet-0-inch in length, shall be used at all manholes and other wall faces, except as otherwise specified.
30. Field painting shall be accomplished after joints are made.
31. All piping shall be plugged watertight with a suitable cap or plug securely fastened to the end of the piping at all contact interfaces.
32. On steep slopes, take measures acceptable to ENGINEER to prevent movement of the pipe during installation.
33. Thrust Restraint: During the installation of the pipe, thrust blocks, tied joints, or proprietary restrained joint systems shall be provided wherever required for thrust restraint. Thrust restraint shall conform to the applicable requirements of Article 3.4, below.
34. Exercise care to avoid flotation when installing pipe in cast-in-place concrete.
35. For copper tubing and thermoplastic piping, snake piping in trench to compensate for thermal expansion.

B. Manufacturer's Installation Specialist:
   1. Provide the services of a competent installation specialist of the pipe manufacturer when pipe laying commences if CONTRACTOR is not experienced in laying and jointing a particular type of pipe for the following:
      a. Concrete pipe.
      b. FRP pipe.
      c. Thermoplastic pipe.
      d. Centrifugally cast, fiberglass-reinforced polymer mortar pipe.
   2. Retain installation specialist at the site for a minimum of 5 days or until competency of the pipe laying crew has been satisfactorily demonstrated to the OWNER and ENGINEER.

C. Separation of Sewers and Potable Water Pipe Lines:
   1. Conform to requirements of MAG Specification Section 610.5

D. Plugs:
   1. Temporarily plug installed pipe at the end of each day's Work or other interruption to the installation of any pipeline. Plugging shall prevent the entry of animals, liquids or persons into the pipe or the entrance or insertion of deleterious materials.

2. Install standard plugs into all bells at dead ends, tees or crosses. Cap all spigot ends.
3. Fully secure and block all plugs and caps installed for pressure testing to withstand the specified test pressure.
4. Where plugging is required for phasing of the Work or for subsequent connection of piping, install watertight, permanent type plugs.

E. Laying Pipe:
1. Conform to manufacturer's instructions and requirements of the standards listed below, where applicable:
   a. Ductile Iron Pipe: AWWA C600, AWWA C105.
   b. Concrete Pipe: AWWA M9, Concrete Pipe Handbook.
   c. Steel Pipe: AWWA M11, AWWA C206.
   d. Thermoplastic Pipe: ASTM D 2774.
   e. Fiberglass Reinforced Polymer Mortar Pipe: AWWA C950.
   f. ASCE Manual of Practice No. 37.

F. Polyethylene Encasement:
1. Provide polyethylene encasement for ductile iron piping to prevent contact between the pipe and surrounding bedding material and backfill.
2. Polyethylene may be supplied in tubes or in sheet material.
3. Polyethylene encasement materials and installation shall be in accordance with the requirements of MAG Section 610.5.

G. Jointing Pipe:
1. Ductile Iron Mechanical Joint Pipe:
   a. Comply with requirements of Section 15101, Ductile Iron Pipe.
   b. Wipe clean the socket, plain end and adjacent areas immediately before making joint. Make certain that cut ends are tapered and sharp edges are filed off smooth.
   c. Lubricate the plain ends and gasket with soapy water or an approved pipe lubricant, in accordance with AWWA C111, just prior to slipping the gasket onto the plain end of the joint assembly.
   d. Place the gland on the plain end with the lip extension toward the plain end, followed by the gasket with the narrow edge of the gasket toward the plain end.
   e. Insert the pipe into the socket and press the gasket firmly and evenly into the gasket recess. Keep the joint straight during assembly.
   f. Push gland toward socket and center it around pipe with the gland lip against the gasket.
   g. Insert bolts and hand tighten nuts.
   h. Make deflection after joint assembly, if required, but prior to tightening bolts. Alternately tighten bolts 180 degrees apart to seat the gasket evenly. The bolt torque shall be as follows:

Pipe Size (inches)	Bolt Size (inches)	Range of Torque (ft-lbs)
3	5/8	45 to 60
4 to 24	3/4	75 to 90
30 to 36	1	100 to 120
42 to 48	1-1/4	120 to 150

i. All bolts and nuts shall be heavily coated with two 10-mil minimum coats of coal-tar epoxy coating as manufactured by Tnemec, or equal.
j. Restrained mechanical joints shall be in accordance with Section 15101, Ductile Iron Pipe.

2. Ductile Iron Push-On Joint Pipe:
   a. Comply with requirements of Section 15101, Ductile Iron Pipe.
   b. Prior to assembling the joints, the last 8-inches of the exterior surface of the spigot and the interior surface of the bell shall be thoroughly cleaned with a wire brush, except where joints are lined or coated with a special protective lining or coating.
   c. Rubber gaskets shall be wiped clean and flexed until resilient. Refer to manufacturer's instructions for procedures to ensure gasket resiliency when assembling joints in cold weather.
   d. Insert gasket into joint recess and smooth out the entire circumference of the gasket to remove bulges and to prevent interference with the proper entry of the spigot of the entering pipe.
   e. Immediately prior to joint assembly, apply a thin film of approved lubricant to the surface of the gasket which will come in contact with the entering spigot end of pipe. Option, apply a thin film of lubricant to the outside of the spigot of the entering pipe.
   f. For assembly, center spigot in the pipe bell and push pipe forward until it just makes contact with the rubber gasket. After gasket is compressed and before pipe is pushed or pulled all the way home, carefully check the gasket for proper position around the full circumference of the joint. Final assembly shall be made by forcing the spigot end of the entering pipe past the rubber gasket until it makes contact with the base of the bell. When more than a reasonable amount of force is required to assemble the joint, the spigot end of the pipe shall be removed to verify the proper positioning of the rubber gasket. Gaskets which have been scoured or otherwise damaged shall not be used.
   g. Maintain an adequate supply of gaskets and joint lubricant at the site at all times when pipe jointing operations are in progress.
3. Proprietary Joints:
   a. Pipe which utilizes proprietary joints such as Megalug, by EBBA Iron, Inc.; Lok-Ring, by American Cast Iron Pipe Company; restrained joints described under Article 3.4, or other such joints shall be installed in strict accordance with the manufacturer's instructions.
4. Flanged Joints:

a. Assemble flanged joints using 1/8-inch ring-type gaskets for raised face flanges. Use full face gaskets for flat face flanges, unless otherwise approved by ENGINEER. Gaskets shall be suitable for the service intended in accordance with the manufacturer's ratings and instructions. Gaskets shall be properly centered.
b. Bolts shall be tightened in a sequence which will ensure equal distribution of bolt loads.
c. The length of bolts shall be uniform, and they shall not project beyond the nut more than 1/4-inch or fall short of the nut when fully taken up. The ends of bolts shall be machine cut so as to be neatly rounded. No washers shall be used.
d. Bolt threads and gasket faces for flanged joints shall be lubricated prior to assembly.
e. After assembly, coat all bolts and nuts with two 8-mil coats of a high-build epoxy or bituminous coating as manufactured by Tnemec, or equal.

5. Prestressed Concrete Cylinder Pipe Joints:
   a. Immediately before making the joint, completely clean the bell and spigot surfaces to be jointed.
   b. Apply a lubricant supplied by the pipe manufacturer to the sealing surfaces of the bell and spigot and the gasket. After lubrication, install the gasket in the spigot groove and ensure that the stretch in the gasket is equalized.
   c. After the pipe is lowered into place, align the spigot and bell so that the spigot will squarely enter the bell.
   d. Before the joint is fully assembled, check the position of the gasket in the bell using methods recommended by the pipe manufacturer and approved by the ENGINEER.
   e. If the gasket is found to be in the correct position around the entire circumference of the bell, remove temporary joint stoppers, if used, and shove the pipe completely home. If the gasket is not in the proper location, the joint shall be opened and reinstalled using a new gasket.
   f. Where a joint opening is required to make a grade or alignment adjustment, the joint shall be installed completely closed first, then opened as necessary on one side. Joint openings shall not be greater than 75 percent of the maximum opening recommended by the pipe manufacturer.
   g. Strap a diaper to the outside of the completed joint straddling the external joint recess. Pour a grout mix consisting of Portland cement and sand in proportions recommended by the pipe manufacturer to completely fill the external joint recess. In lieu of the joint diaper, with written approval of the pipe manufacturer, use a polyurethane foam joint protector with unhydrated Portland cement dispersed throughout the protector. The protector shall have the cross-sectional shape required for the type of joint being installed and shall be formed in a loop to fit the size of pipe on which it is to be used.
   h. Point interior joint recess of all pipe 24-inches in diameter and larger with Portland cement/sand mortar mixed in proportions recommended by the pipe manufacturer. Strike off grout smooth with the interior face of the pipe. For pipes 20-inches in diameter and smaller which convey sewage or

nonpotable water, the interior surfaces of the steel joint ring shall be protected by a flexible mastic joint filler applied to the bell socket just prior to joining the pipe such that the mastic squeezes out to fill the internal joint recess.

i. Coat all exterior exposed steel portions of the pipe, flanges, couplings, bolts and nuts with two 8-mil coats of high-build epoxy or bituminous coating as manufactured by Tnemec, or equal.

j. Maintain a sufficient quantity of joint lubricant, gaskets, joint diapers and joint fillers at the site of the Work at all times.

k. Do not use gaskets which have been scored or otherwise damaged.

l. Where welded joints are required to handle thrust, the steel spigot shall be cut at the trailing edge of the gasket groove to provide a surface suitable for welding in the field. All field welded joints shall be full circumferential welds designed to take the thrust at the joint location. A minimum 3/16-inch weld is required. The exposed steel surface of the pipe joints shall have a temporary protection system of a rust and corrosion inhibitor applied which need not be removed prior to welding. After welding is complete, the joint protection shall be completed with interior and exterior cement mortar grouting.

6. Steel Pipe Joints:
   a. Joints in steel pipe shall be butt welded joints, except that flexible couplings, mechanical couplings, or flanged connections shall be provided at connections to valves, meters and similar equipment.
   b. Welding shall conform to the requirements of AWWA C206. Pipe 36-inches in diameter and larger shall be welded both inside and outside of the pipe.
   c. After welding, the joint and the surrounding damaged or uncoated area shall be coated with the same material and to the same thickness as the shop applied coating.
   d. Where flanged connections or couplings are provided, the flanges, couplings, bolts and nuts shall be coated with two 8-mil coats of high-build epoxy or bituminous coating as manufactured by Tnemec, or equal.
7. Thermoplastic Pipe Joints:
   a. Solvent Cement Joints:
      1) Bevel pipe ends and remove all burrs before making joints. Clean both pipe and fittings thoroughly. Do not attempt to make solvent cement joints if temperature is below 40°F or above 90°F when exposed to direct sunlight or in wet conditions.
      2) Use solvent cement supplied or recommended by the pipe manufacturer.
      3) Apply joint primer and solvent cement and assemble joints in strict accordance with the recommendations and instructions of the manufacturer of the joint materials and the pipe manufacturer.
      4) Observe safety precautions with the use of joint primers and solvent cements. Allow air to circulate freely through pipelines to permit

solvent vapors to escape. Slowly admit water when flushing or filling pipelines to prevent compression of gases within pipes.

b. Push-On Joints:
   1) Bevel all field-cut pipes, remove all burrs and provide a reference mark the correct distance from the pipe end.
   2) Clean the pipe end and the bell thoroughly before making the joint. Insert the O-ring gasket, making certain it is properly oriented. Lubricate the spigot well with an approved lubricant; do not lubricate the bell or O-ring. Insert the spigot end of the pipe carefully into the bell until the reference mark on the spigot is flush with the bell.

8. Copper Tubing Joints:
   a. Assemble copper tubing with soldered joints. Solder shall be 95-5 tin-antimony solder conforming to ASTM B 32.
   b. Ream or file pipe to remove burrs.
   c. Clean and polish contact surfaces of joints.
   d. Apply flux to both male and female ends.
   e. Insert end of tube into full depth of fitting socket.
   f. Heat joint evenly.
   g. Form continuous solder bead around entire circumference of joint.
   h. Runs shall contain unions at connection to equipment and at reasonable distances along the lengths of runs to permit convenient disassembly of piping and removal of equipment.
9. Mechanical Coupling Joints:
   a. Prior to the installation and assembly of mechanical couplings, the joint ends shall be cleaned thoroughly with a wire brush to remove foreign matter. Following this cleaning, lubricant shall be applied to the rubber gasket or inside of the coupling housing and to the joint ends. After lubrication, the gasket shall be installed around the joint end of the previously installed piece and the joint end of the subsequent piece shall be mated to the installed piece. The gasket shall be positioned and the coupling housing placed around the gasket and over the grooved or shouldered joint ends. The bolts shall be inserted and the nuts screwed up tightly by hand. The bolts shall then be tightened uniformly in order to produce an equal pressure on all parts of the housing. When the housing clamps meet metal to metal, the joint is complete and further tightening is not required.
10. HDPE Double Containment Pipe (Containment and Carrier Pipe):
   a. Joints of double containment piping system shall be installed in strict accordance with the manufacturer's instructions and shall be of the butt fusion process.

H. Connections to Valves and Hydrants:
   1. Install valves and hydrants as shown on the Drawings. Valves shall be located in such a way that they are accessible for repair and removal in the future.
   2. Provide suitable adapters when valves or hydrants and piping have different joint types.

3. Provide thrust restraint at all hydrants and at valves at pipeline terminations.

I. Transitions from One Type of Pipe to Another:
1. Provide all necessary adapters, specials and connection pieces required when connecting different types and sizes of pipe or connecting pipe made by different manufacturers.

J. Closures:
1. Provide all closure pieces shown on the Drawings or required to complete the Work.

3.5 THRUST RESTRAINT

A. Provide thrust restraint on all pressure piping systems and where otherwise shown on the Drawings and specified. Refer to Section 03200, Concrete Reinforcement.

B. Thrust restraint shall be accomplished by means of restrained pipe joints. Concrete thrust blocks shall be used only when specifically shown on the Drawings or as directed by the ENGINEER. Thrust restraints shall be designed for the axial thrust exerted by the test pressure for each piping system as specified in Section 15050, Piping Systems.

C. Restrained Pipe Joints:
1. Pipe joints shall be restrained by means suitable to the type of pipe being installed.
   a. Prestressed concrete cylinder pipe shall be restrained utilizing welded joints. Concrete pipe requiring restraint shall have sufficient longitudinal steel reinforcement provided to handle the thrust forces at a maximum design stress of 12,500 psi. The thrust forces in the longitudinales must be transmitted directly to the steel joint bands using welded connections sufficient to carry the stresses involved. No allowance for the concrete to handle any tensile forces is permitted.
   b. Ductile-iron push on joints and mechanical joints shall be restrained utilizing a proprietary restrained joint system such as American Lok-Ring, Ebba Iron, Inc., Series 1100 Megalug, U.S. Pipe TR Flex System, lugs, and tie rods, or other system approved by ENGINEER.
   c. Steel pipe shall have butt-welded joints, flanged joints, or flexible or mechanical coupling connectors as specified in Section 15050, Piping Systems. Tie rods connected to ears welded to the steel pipe shall be provided for restraint at all flexible coupling connectors.
   d. Thermoplastic and copper piping shall generally be installed with soldered, solvent weld, threaded, flanged, or similar type joints. Where push-on type or other non-restrained joints are used, provide tie rods or other suitable joint restraint system for these joints, subject to the approval of ENGINEER.

e. Harnessed lengths for buried pipe shall be determined by the pipe manufacturer in accordance with the formula for determination of buried pipe harnessed lengths located at the end of this Section.
f. Concrete cylinder pipe thrust restraint shall be in accordance with AWWA Manual M-9, Chapter 7.

D. Concrete Thrust Blocks:
1. Thrust blocks shall be constructed of Type 2 concrete.
2. Blocks shall be placed against undisturbed soil as shown on Drawings or as directed by the ENGINEER. Concrete shall be placed so that pipe joints and fitting joints will be accessible for repair.
3. Size of concrete thrust blocks shall be as shown on the Drawings, or as directed and approved by ENGINEER.
4. Provide concrete thrust blocks on pressure piping at all changes in alignment of 15 degrees or more, at all tees, plugs and caps and where shown on the Drawings.

3.6 BACKFILL

A. General
1. Backfill begins after the placement of the pipe bedding/granular embedment. Pipeline trenches may be backfilled prior to pressure testing, but no structure shall be constructed over any pipeline until it has been tested.
2. Place and compact backfill as construction progresses.
3. Compacted backfill shall be required for the full depth of the trench above the granular pipe embedment material. Where the trench for one pipe passes beneath the trench for another pipe or electrical duct bank, the lower trench shall be compacted to the level of the bottom of the upper trench.
4. Each layer of backfill material shall be compacted by at least two complete coverages of all portions of the surface of each lift using approved compaction equipment. One coverage is defined as the conditions reached when all portions of the fill lift have been subjected to the direct contact of the compacting surface of the compactor.
5. The method of compaction and the equipment used shall be appropriate for the material to be compacted and shall not transmit damaging shocks to the pipe.
6. The degree of compaction required for all types of fills shall be as listed below. Material shall be moistened or aerated as necessary to provide the moisture content that will facilitate obtaining the specified compaction.
7. The trench backfill shall be thoroughly compacted to no less than the following densities when tested and determined by ASSHTO T-99 and T-191 or ASTM D 2922 and D 3017. When ASSHTO T-99, Method A or B, and T-191 are used for density determination, MAG Detail 190 will be used for rock correction. The minimum density required is identified below:

MATERIAL THICK. (IN)	Required Minimum Density-Percent Compaction (ASTM D 698)	Maximum Uncompacted LIFT (INCHES)
Aggregate Base Course:		
Below asphalt paving	100	8
Trench Backfill above pipe:	95	12
Granular Pipe Embedment Material:	100	6
Sand Embedment Material:	95	6

All fill must be wetted and thoroughly mixed to achieve optimum moisture content, ± three percent, with the following exceptions: On site clayey soils optimum to plus three percent.

Natural undisturbed soils or compacted soil subsequently disturbed or removed by construction operations shall be replaced with materials compacted as specified above.

3.7 GRADING

A. General: Uniformly grade areas within limits of grading shown on the Drawings or specified, including adjacent transition areas. Smooth subgrade surface within specified tolerances, compact with uniform levels or slopes between points where elevations are shown on the Drawings, or between such points and existing grades.

B. Turfed Areas: Finish areas to receive topsoil to within not more than 1-inch above or below the required subgrade elevations.

C. Walks: Shape surface of areas under walks to line, grade and cross-section, with finish surface not more than 1-inch above or below the required subgrade elevation.

D. Pavements: Shape surface of areas under pavements to line, grade and cross-section, with finish surface not more than 1/2-inch above or below the required subgrade elevation.

E. Slabs: Grade smooth and even, free of voids, compacted as specified, and to required elevation. Provide final grades within a tolerance of 1/2-inch when tested with a 10-foot straightedge.

F. Compaction: After grading, compact subgrade surfaces to the depth and percentage of maximum density required.

3.8 PAVEMENT SUBBASE COURSE

A. General: Place subbase material, in layers of specified thickness, over ground surface to support pavement base course.
   1. Refer to Section 02742, Bituminous Paving.

B. Grade Control: During construction, maintain lines and grades including crown and cross-slope of subbase course.

C. Shoulders: Place shoulders along edges of subbase course to prevent lateral movement. Construct shoulders of acceptable soil materials, placed in such quantity to compact to thickness of each subbase course layer. Compact and roll at least a 12-inch width of shoulder simultaneously with compacting and rolling of each layer of subbase course.

D. Placing: Place subbase course material on prepared subgrade in layers of uniform thickness, conforming to indicated cross-section and thickness. Maintain optimum moisture content for compacting subbase material during placement operations.
   1. When a compacted subbase course is shown on the Drawings to be 6-inches thick or less, place material in a single layer. When shown on the Drawings to be more than 6-inches thick, place material in equal layers, except no single layer more than 6-inches or less than 3-inches in thickness when compacted.

3.9 DISPOSAL OF EXCAVATED MATERIALS

A. Material removed from the excavations which does not conform to the requirements for fill or is in excess of that required for backfill shall be hauled away by CONTRACTOR and disposed of in compliance with municipal, county, state, federal or other applicable regulations at no additional cost to OWNER.

3.10 RESTORING AND RESURFACING EXISTING ROADWAYS AND FACILITIES

A. Place 1-1/2 inches of temporary bituminous pavement immediately after backfilling trenches in paved roadways. Maintain the surface of the paved area over the trench in good and safe condition during progress of the entire Work, and promptly fill all depressions over and adjacent to the trench caused by settlement of backfill. Immediately prior to constructing the permanent paving and base, remove and dispose of temporary pavement. Permanent replacement pavement shall be equal to that of the existing roadways unless otherwise shown on the Drawings or specified.

B. Pavement, gutters, curbs, walks, driveways and roadways disturbed or damaged by CONTRACTOR'S operations, except areas designated "New Pavement" or "Proposed Pavement", shall be restored or replaced at CONTRACTOR’S expense to as good condition as they were previous to the commencement of the Work and in accordance with applicable local and state highway specifications.

3.11 WORK AFFECTING EXISTING PIPING

A. Location of Existing Piping:
   1. Locations of existing piping shown on the Drawings should be considered approximate.
   2. Determine the true location of existing piping to which connections are to be made, and location of other facilities which could be disturbed during earthwork operations, or which may be affected by CONTRACTOR'S Work already installed.
   3. Conform to applicable requirements of Division 1, General Requirements, pertaining to cutting and patching, and connections to existing facilities.

B. Taking Existing Pipelines Out of Service:
   1. Do not take pipelines out of service unless specifically listed below, or approved by ENGINEER.
      a. Refer to Section 01143, Coordination with OWNER'S Operations.
   2. Notify ENGINEER at least 48 hours prior to taking any pipeline out of service.

C. Work on Existing Pipelines:
   1. Cut or tap pipes as shown on the Drawings or required with machines specifically designed for this Work. All taps shall be made at the spring line except for air release taps. Taps to buried piping 16-inches in diameter and larger shall be protected by an access vault to the surface or shall be 4-inches larger, with a shut off ball valve and a riser to the surface. Taps made to pipe smaller than 16-inches may be 2-inch taps. Taps shall not be located under slabs.
   2. Install temporary plugs to prevent entry of mud, dirt, water and debris.
   3. Provide all necessary adapters, fittings, pipe and appurtenances required to complete the Work.
   4. Existing pipelines which are cut and abandoned shall be adequately capped or filled with grout.

3.12 TESTING OF PIPING

A. General:
   1. Test all piping, except as otherwise authorized by ENGINEER.
   2. Notify ENGINEER and local authorities having jurisdiction at least 48 hours in advance of testing if their presence is required.
   3. Conduct all tests in the presence of the ENGINEER.
   4. Remove or protect any pipeline-mounted devices which may be damaged by the test pressure.
   5. Provide all apparatus and services required for testing, including but not limited to, the following:
      a. Test pumps, bypass pumps, hoses, calibrated gauges, meters, test containers, valves and fittings.
      b. Temporary bulkheads, bracing, blocking and thrust restraints.

6. Provide air if an air test is required and power if pumping is required.
7. Unless otherwise specified, OWNER will provide fluid required for testing.
8. Repair and retest pipelines that fail to hold specified test pressure or which exceed the allowable leakage rate.
9. Unless otherwise noted, pipelines shall hold specified test pressure for two hours.
10. Unless otherwise specified, test pressures required are at the lowest elevation of the pipeline section being tested.

B. Schedule of Pipeline Tests:
   1. Refer to Section 15050, Piping Systems, for the type of test required and the required hydrostatic test pressure.
   2. Unless otherwise specified, the required hydrostatic test pressures are at the lowest elevation of the pipeline.
   3. For piping not listed in Section 15050, Piping Systems:
      a. Hydrostatically test pipe that will be operating at a pressure greater than five psig.
      b. Use exfiltration testing or low-pressure air testing for all other piping.
   4. Hydrostatic Test Pressure:
      a. Use test pressures listed in Section 15050, Piping Systems.
      b. If a test pressure is not listed in Section 15050, Piping Systems, or if a hydrostatic test is required for piping not listed in Section 15050, Piping Systems, the test pressure will be determined by the ENGINEER based on the maximum anticipated sustained operating pressure and the methods described in the AWWA Manual or Standard which applies to the piping system.

C. Hydrostatic Testing:
   1. Preparation for Testing:
      a. For plastic pipe, including fiberglass pipe, follow procedures described in Section 7 of AWWA Standard C605.
      b. For all other piping follow procedures described in AWWA Manual M9 except that the minimum wetting period required immediately prior to testing for cement-lined steel pipe and asbestos cement pipe shall be 24 hours rather than the 48 hours prescribed for concrete pipe. A wetting period is not required for metal pipe that is not cement-lined or for plastic pipe.
      c. Ensure that adequate thrust protection is in place and that all joints are properly installed.
   2. Test Procedure:
      a. Complete backfill and compaction at least to the pipe centerline before testing, unless otherwise required or approved by ENGINEER.
      b. Allow concrete for thrust blocks to reach design strength before testing.
      c. Fill pipeline slowly to minimize air entrapment and surge pressures. Fill rate should not exceed one foot per second in the pipe being tested. Install corporation cocks, if necessary, to remove all air.

d. Examine exposed joints and valves, and correct visible leakage.
e. After the wetting period prescribed above, add fluid to pressurize line to the required test pressure. Maintain test pressure for a stabilization period of ten minutes before beginning test.
f. After the stabilization period, maintain test pressure for the duration specified in Section 15050, Piping Systems. Add fluid to restore test pressure if pressure drops five psi below test pressure at any time during the test period.
g. Pump from a test container to maintain test pressure. Measure the volume of fluid pumped from the container and record on the test report. Record pressure at the test pump at 15 minute intervals for the duration of the test.

3. Allowable Leakage Rates:
   a. Conduct leakage test for all liquid piping after satisfactory completion of pressure test.
   b. Allow concrete pipe to stand full of water at least 12 hours prior to starting leakage test.
   c. Maintain test pressure constantly for the minimum test period and accurately measure the amount of water which must be added to maintain the test pressure.
   d. Allowable Leakage Rates (in gallons per hour per 1,000 feet per inch diameter):
      1) DIP Push On or Mechanical Joints: 0.075.
      2) Centrifugally Cast, Fiberglass -Reinforced Polymer Mortar Pipe: 0.0.

D. Required Tests for Gravity Sewer and Storm Drains:
   1. Elect to test piping, using either air or water test procedures. Notify ENGINEER, in writing, in advance of all testing, which method he plans to utilize and must follow through with the same method on all pipeline testing.
      a. Gravity sewers shall be tested with either air or water testing; however, storm drains may only be water tested.
      b. Tests shall be performed after backfilling is completed, but shall be performed before final cleanup and acceptance of Work.
      c. Tests shall be performed prior to final acceptance.
         1) Test all piping and manholes for leakage by means of the tests described below.
         2) Test to be performed between adjacent manholes or as approved by the ENGINEER.
      d. Prior to making tests, submit details of his testing procedures, with a description of methods and equipment CONTRACTOR proposes to use, to the ENGINEER for approval. Furnish all necessary labor, equipment, water, watertight bulkheads, rodding machine, generator, pumps and all else necessary to carry out the required tests.
   2. Air Test:
      a. Wet and thoroughly clean the inside of the pipe before test is performed.
      b. Insert test plugs in ends of pipe to be tested.
      c. Securely brace test plugs.

d. Measure and record groundwater height above the pipe invert. All gage pressures in the test shall be increased by the amount of the back pressure due to groundwater submergence.
e. Slowly fill the pipe with air to a pressure of four psig. Maintain pressure between 4 and 3.5 psig for at least two minutes for temperature stabilization.
f. Check all plugs for tightness.
g. With a pressure of approximately four psig in pipe, disconnect air supply.
h. Allow pressure to decrease to 3.5 psig.
i. When the pressure reaches 3.5 psig, record the time required to decrease to 2.5 psig using a stopwatch.
j. The line is considered acceptable if the time for the pressure to decrease from 3.5 psig to 2.5 psig is not less than the amount shown on the following table for the respective pipe diameters.

Minimum Acceptance Times	
Pipe Diameter (Inches)	Time
6	2 min. 50 sec.
8	3 min. 50 sec.
10	4 min. 45 sec.
12	5 min. 40 sec.
14	6 min. 40 sec.
16	7 min. 5 sec.
18	7 min. 35 sec.
20	9 min. 30 sec.
21	9 min. 55 sec.
24	11 min. 20 sec.
27	12 min. 45 sec.

k. If the leakage in the section tested exceeds the specified amount, make the necessary repairs or replacements required to reduce the leakage to within the specified limits and the test shall be repeated until the leakage requirement is met.
l. No one shall be allowed in the manhole during air testing.

3. Water Test:
   a. When water test is performed for reinforced concrete pipe, the test section shall be filled with water and allowed to stand for 24 hours. The water shall then be replenished and the test performed.
   b. Insert test plugs and securely brace.
   c. Fill the pipe and manhole with water to provide a positive differential head on the top of the pipe at the highest point of the pipeline under test of at least the test pressure specified in Section 15050, Piping Systems.
   d. The amount of water added to maintain this head shall be the leakage.
   e. Test for a period of at least four hours.

f. Total leakage of any section tested shall not exceed the following rates:
   1) Gravity Sewer: 0.5 gallons per hour per 100 feet of pipe per inch diameter of pipe.
   2) Storm Drains: 2.0 gallons per hour per 100 feet of pipe per inch diameter of pipe.

g. If the leakage in the section tested exceeds the specified amount, make the necessary repairs or replacements required to reduce the leakage to within the specified limits and the test shall be repeated until the leakage requirements is met.

h. On steep grades it may be necessary to place plugs in the pipe between manholes to avoid excessive pressures in the pipe.

4. Visual Inspection:
   a. Prior to final acceptance, a visual inspection by ENGINEER of all appurtenant structures, (e.g., manholes, chambers, etc.), shall be required. Any visual leaks, regardless of their magnitude shall be repaired by CONTRACTOR.

5. Watertight Sewers:
   a. It is imperative that all sewers and appurtenant structures be constructed as watertight as practicable. Adhere rigidly to all requirements of the Contract Documents and follow all directions of the ENGINEER to secure a watertight sewer. If, during the Work or after its completion, any leaks are discovered, they shall be repaired in a satisfactory manner at the expense of CONTRACTOR even though the pipe and appurtenant structures may have already successfully passed the leakage tests.

E. Vertical Deflection Test for Thermoplastic Pipe:
   1. The vertical deflection test shall be conducted after the final backfill has been in place at least 30 days.
   2. Manually pull a pin-type vertical gauge mounted on a sled through the pipe. Gauge shall be set so that if vertical deflection of pipe exceeds five percent, it will stop. Excavate and reinstall all such piping. Gauge shall be as manufactured by Quality Test Products, or equal.

3.13 DISPOSAL OF WATER

A. Provide suitable means for disposal of test and flushing water so that no damage results to facilities or waterways.

B. Means of disposal of test and flushing water shall be subject to the approval of ENGINEER, local governing authorities and regulatory agencies.

C. Responsibility belongs to CONTRACTOR for any damage caused by water disposal operations.

3.14 CLEANING AND DISINFECTION

A. Cleaning:
   1. Thoroughly clean all piping and flush in a manner approved by ENGINEER, prior to placing in service.
   2. Piping 24-inches in diameter and larger shall be inspected from inside and all debris, dirt and foreign matter removed.
   3. If piping which requires disinfection has not been kept clean during storage or installation, swab each section individually before installation with a five percent hypochlorite solution, to ensure clean piping.

B. Disinfection:
   1. Disinfect all potable and finished water piping. Comply with requirements of Section 15141, Potable Water Piping System, and Section 15142, Disinfection, Plumbing.
   2. A suggested procedure for accomplishing complete and satisfactory disinfection is specified below. Other procedures will be considered for approval by the ENGINEER.
      a. Thoroughly flush piping prior to disinfection with water. For pipelines 24-inches in diameter and larger, pipelines shall be manually cleaned, carefully removing all sweepings, dirt and debris prior to disinfection.
      b. Conform to procedures described in AWWA C 651. Continuous feed method of disinfecting shall be used, unless alternative method is acceptable to ENGINEER.
   3. Water for initial flushing, testing and chlorination will be furnished by the OWNER. Provide all temporary piping, hose, valves, appurtenances and services required. Cost of water required for redisinfection will be paid by CONTRACTOR to OWNER at OWNER'S standard rates.
   4. Chlorine will be supplied by CONTRACTOR.
   5. Bacteriologic tests will be performed by OWNER. A certified test laboratory report will be made available to CONTRACTOR, if requested.
   6. Chlorine concentration in the water entering the piping shall be between 50 and 100 parts per million, such that a minimum residual concentration of 25 mg/l will be left after a 24-hour retention period. Care shall be taken to ensure disinfection of the piping in all its parts. The operation shall be repeated as necessary to provide complete disinfection.
   7. After the required retention period, the heavily chlorinated water shall be flushed to drain, unless otherwise directed by the ENGINEER.

3.15 INSTALLATION OF DETECTABLE PIPE LOCATING TAPE

A. Underground Pipe Locating Tape:
   1. Refer to paragraph 2.3.A of this Section, and Section 15050, Piping Systems.
   2. Detectable pipe locating tape shall be placed above all underground pipelines. Tape shall be buried 12-inches below finished grade directly above entire pipeline length.

3. Detectable pipe locating tape for reuse water shall be buried on top and in contact with the pipe in addition to 12-inches below finished grade.

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FORMULA FOR DETERMINATION OF BURIED PIPE HARNESSED LENGTHS

Lengths shall be based on the following:

$$\text{HARNESSED LENGTH (L) on each side of bend} = \frac{T}{f \sum W}$$

$T = 1.25\ PA \sin \Delta/2$

T = Thrust (lbs)

P = Test Pressure (psi), refer to Section 15050, Piping Systems.

A = Pipe Area (sq.in.)

Δ = Angle of Bend

f = friction factor between soil and pipe = 0.3*

$\sum W = W_p + W_s + W_w$

W_p = weight pipe (pounds per linear foot-PLF)

W_s = weight soil (PLF)**

W_w = weight fluid (PLF)

* For ductile iron and steel pipe: friction factor = 0.1.

** Based on depth of cover on pipe, and outside diameter of pipe. Soil weight = 100 pcf.

+ + END OF SECTION + +

SECTION 15052

EXPOSED PIPING INSTALLATION

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish and install and test all exposed piping, fittings, and specials. The Work includes, but is not limited to, the following:
      a. All types and sizes of exposed piping, except those specified under other Sections.
      b. Piping embedded in concrete within a structure or foundation will be considered as exposed and included herein.
      c. Supports, restraints, thrust blocks and other anchors.
      d. Work on or affecting existing piping.
      e. Testing.
      f. Cleaning and disinfecting.
      g. Installation of all jointing and gasketing materials, specials, flexible couplings, mechanical couplings, harnessed and flanged adapters, sleeves, tie rods, and all other Work required to complete the exposed piping installation.
      h. Incorporation of valves, meters and special items shown on the Drawings or specified into the piping systems as required and as specified in the appropriate Division 15, Mechanical, Sections.
      i. Unless otherwise specifically shown on the Drawings, specified, or included under other Sections, all exposed piping Work required, beginning at the outside face of structures or structure foundation and extending into the structure.

B. Coordination:
   1. Review installation procedures under other Sections and coordinate with the Work that is related to this Section.
   2. Section 15052, Exposed Piping Installation, specifies the installation of all exposed piping materials specified in Division 15, Mechanical. Coordinate with these Sections.

1.2 QUALITY ASSURANCE

A. Requirements of Regulatory Agencies:
   1. Comply with applicable requirements of NFPA Standard No. 13 for "Installation of Sprinkler Systems" and NFPA Standard No. 14 for "Standpipe and Hose Systems" used for fire protection.

2. Comply with requirements of UL, FM and other jurisdictional authorities, where applicable.
3. Refer to the General and Supplementary Conditions regarding requirements for this Project.
4. Phoenix Building Code.

B. Reference Standards: Comply with applicable provisions and recommendations of the following, except as otherwise shown or specified.
1. ANSI B 16.3, Malleable-Iron Threaded Fittings, Classes 150 and 300.
2. ANSI B 16.4, Cast Iron Threaded Fittings, Classes 125 and 250.
3. ANSI B 16.5, Pipe Flanges and Flanged Fittings, Steel Nickel Alloy and Other Special Alloys.
4. ANSI B 16.9, Factory-Made Wrought Steal Butt Welding Fittings.
5. ANSI B 16.11, Forged Steel Fittings, Socket-Welding and Threaded.
6. ANSI B 31.1, Power Piping.
7. ANSI B 31.3, Chemical Plant and Petroleum Refinery Piping.
8. ANSI B 31.8, Gas Transmission and Distribution Piping Systems.
9. AWWA C 111, Rubber Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
10. AWWA C 206, Field Welding of Steel Water Pipe Joints.
11. AWWA C 600, Installation of Ductile Iron Water Mains and Their Appurtenances.
12. AWWA C 606, Grooved and Shouldered Type Joints.
13. AWWA C 651, Disinfecting Water Mains.
14. AWWA M9, Concrete Pressure Pipe.
15. AWWA M11, Steel Water Pipe Design and Installation.
16. AWWA M23, PVC Piping.
17. AWS D 1.1, Structural Welding Code.
18. AWS D 10.7, Recommended Practices For Gas Shielded-Arc Welding of Aluminum and Aluminum Alloy Pipe.
19. AWS D 10.9, Standard for Qualification of Welding Procedures and Welders for Piping and Tubing.
20. ASME Boiler and Pressure Vessel Code.
21. NFPA 13, Installation of Sprinkler Systems.
22. NFPA 14, Standpipe and Hose Systems.
23. NFPA 54, National Fuel Gas Code.
24. Phoenix Building Code.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
1. Detailed drawings in plan and section, and laying schedules.
2. Details of piping, valves, supports, accessories, specials, joints, harnessing, and connections to existing pipes and structures.

B. Tests: Submit description of proposed testing methods, procedures and apparatus. Submit copies of test report for each test.

C. Certificates: Submit certificates of compliance with referenced standards.
   1. Welder's Certificate to comply with the requirements of Paragraph 3.1.D.5.b.1) of this Section, below.

D. Record Drawings:
   1. Submit Record Drawings prior to the time of Substantial Completion.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Deliver materials to the site to ensure uninterrupted progress of the Work.

B. Handle all pipe, fittings and accessories carefully with approved handling devices. Do not drop or roll pipe off trucks. Do not otherwise drop, roll or skid piping.

C. Store pipes and fittings on heavy wood blocking or platforms so they are not in contact with the ground.

D. Unload pipe, fittings and specials opposite to or as close to the location where they are to be installed as is practical to avoid unnecessary handling. Keep pipe interiors completely free from dirt and foreign matter.

E. Inspect delivered pipe for cracked, gouged, chipped, dented or other damaged material and immediately remove from site.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Required pipe materials are listed in Section 15050, Piping Systems. Refer to applicable Sections for material specifications.

B. General:
   1. Marking Piping:
      a. Clearly mark each piece of pipe or fitting with a designation conforming to that shown on the approved Shop Drawings.
      b. Cast or paint material, type and pressure designation on each piece of pipe or fitting 4-inches in diameter and larger.
      c. Pipe and fittings smaller than 4-inches in diameter shall be clearly marked by manufacturer as to material, type and rating.

C. Responsibility to coordinate compatible materials of construction for all elastomer components for all seats, seals, gaskets, etc., for each process application belongs to

CONTRACTOR. Acceptable compatible materials of construction for all elastomer materials are as follows:

Process Fluid	Compatible Materials of Construction
Ferric Chloride	Buna, EPDM, Teflon, Viton
Hydrochloric Acid	Teflon, Viton
Sodium Hydroxide	Teflon, Hypalon, Polypropylene
Sodium Hypochlorite	Teflon, PVDF, Hypalon, Polypropylene
Polymer	Viton, Teflon
Methanol	Buna-N, Teflon

D. Pipe Identification Markers and Arrows: Refer to Section 09900, Painting.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General:
1. Install piping as shown on the Drawings, specified and as recommended by the manufacturer.
2. If there is a conflict between manufacturer's recommendations and the Contract Documents, request instructions from ENGINEER before proceeding.

B. Manufacturer's Installation Specialist:
1. Provide the services of a competent installation specialist of the pipe manufacturer when pipe installation commences, if CONTRACTOR is not experienced installing a particular type of pipe, for the following:
   a. FRP pipe.
   b. Thermoplastic pipe.
2. Retain installation specialist at the site for a minimum of 5 days or until competency of the pipe installation crew has been satisfactorily demonstrated to the OWNER and ENGINEER.

C. Piping Installation:
1. Install straight runs true to line and elevation.
2. Install vertical pipe truly plumb in all directions.
3. Install piping parallel or perpendicular to building walls. Piping at angles and 45 degree runs across corners will not be accepted, unless specifically shown on the Drawings or approved by the ENGINEER.
4. Install small diameter piping generally as shown on the Drawings when specific locations and elevations are not indicated. Locate such piping as required to avoid ducts, equipment, beams, and other obstructions.

5. Install piping so as to leave all corridors, walkways, work areas, and like spaces unobstructed. Unless otherwise approved by the ENGINEER, provide a minimum headroom clearance under all piping of 7 feet-6 inches.
6. Protect and keep clean water pipe interiors, fittings and valves.
7. Provide temporary caps or plugs over all pipe openings at the end of each day's work, and when otherwise required or directed by ENGINEER.
8. Cutting: Cut pipe from measurements taken at site, not from Drawings.
9. Install dielectric unions or dielectric flange kits with sleeves and washers wherever dissimilar metals are connected, except for bronze or brass valves in ferrous piping.
10. Provide a union downstream of each valve with screwed connections.
11. Provide screwed or flanged unions at each piece of equipment, where shown on the Drawings, and where necessary to install or dismantle piping.
12. Additional Requirements for FRP and Thermoplastic Piping:
    a. Support all valves independently of the piping system.
    b. Utilize wide band supports as recommended by manufacturer and approved by ENGINEER to minimize localized stresses.
    c. Provide piping passing through walls with a sleeve of wearing material to prevent abrasion damage to piping.
    d. When anchors are required at locations other than equipment or tanks they shall be placed at elbows, valve locations and at bends in pipe line.
    e. Spacing of supports shall be in accordance with the manufacturer's published recommendations at the maximum design operating temperature of the pipe and requirements of Section 15061, Pipe Hangers and Supports.
    f. Use "U" clamps with wide band circumferential contact.
    g. Use guides on long runs of piping to maintain alignment and reduce chance of elastic failure of pipe. Space guides as recommended by manufacturer.
    h. Expansion compensation shall comply with the requirements of Section 15061, Pipe Hangers and Supports.
    i. Provide air chambers with shut-off and drain valve on all pump discharge lines to reduce hydraulic hammer and flexible connectors to absorb vibration. Submit details for ENGINEER to review.
    j. Do not install pipe when temperature is less than 60°F.

D. Joints:
1. General:
    a. Make joints in accordance with the pipe manufacturer's instructions and recommendations and the requirements below.
    b. Cut piping accurately and squarely and install without forcing or springing.
    c. Ream out all pipes and tubing to full inside diameter after cutting. Remove all sharp edges on end cuts.
    d. Remove all cuttings and foreign matter from the inside of pipe and tubing before installation. Thoroughly clean all pipe, fittings, valves, specials, and accessories before installing.
2. Mechanical Joint Pipe:

a. Wipe clean the socket, plain end and adjacent areas immediately before making joint. Make certain that cut ends are tapered and sharp edges are filed off smooth.
b. Lubricate the plain end and gasket with soapy water or manufacturer's recommended pipe lubricant, in accordance with AWWA C 111, just prior to slipping the gasket onto the plain end of the joint assembly.
c. Place the gland on the plain end with the lip extension toward the plain end, followed by the gasket with the narrow edge of the gasket toward the plain end.
d. Insert the pipe into the socket and press the gasket firmly and evenly into the gasket recess. Keep the joint straight during assembly.
e. Push gland toward socket and center it around pipe with the gland lip against the gasket.
f. Insert bolts and hand tighten nuts.
g. Make deflection after joint assembly, if required, but prior to tightening bolts. Alternately tighten bolts 180 degrees apart to seat the gasket evenly. The bolt torque shall be as follows:

Pipe Size (inches)	Bolt Size (inches)	Range of Torque (ft-lbs)
3	5/8	45 to 60
4 to 24	3/4	75 to 90
30 to 36	1	100 to 120
42 to 48	1-1/4	120 to 150

3. Flanged Joints:
   a. Assemble flanged joints using 1/8-inch ring-type gaskets for raised face flanges. Use full face gaskets for flat face flanges, unless otherwise approved by ENGINEER. Gaskets shall be suitable for the service intended in accordance with the manufacturer's ratings and instructions. Gaskets shall be properly centered.
   b. Bolts shall be tightened in a sequence which will ensure equal distribution of bolt loads.
   c. The length of bolts shall be uniform, and they shall not project beyond the nut more than 1/4-inch or fall short of the nut when fully taken up. The ends of bolts shall be machine cut so as to be neatly rounded. No washers shall be used.
   d. Bolt threads and gasket faces for flanged joints shall be lubricated prior to assembly as recommended by manufacturer.
   e. Alternately tighten bolts 180 degrees apart to compress the gasket evenly.
4. Prestressed Concrete Cylinder Pipe Joints:
   a. Immediately before making the joint, completely clean the bell and spigot surfaces to be jointed.

b. Apply a lubricant supplied by the pipe manufacturer to the sealing surfaces of the bell and spigot and the gasket. After lubrication, install the gasket in the spigot groove and ensure that the stretch in the gasket is equalized.
c. After the pipe is lowered into place, align the spigot and bell so that the spigot will squarely enter the bell.
d. Before the joint is fully assembled, check the position of the gasket in the bell using methods recommended by the pipe manufacturer and approved by the ENGINEER.
e. If the gasket is found to be in the correct position around the entire circumference of the bell, remove temporary joint stoppers, if used, and shove the pipe completely home. If the gasket is not in the proper location, the joint shall be opened and reinstall using a new gasket.
f. Where a joint opening is required to make a grade or alignment adjustment, the joint shall be installed completely closed first, then opened as necessary on one side. Joint openings shall not be greater than 75 percent of the maximum openings recommended by the pipe manufacturer.
g. Strap a diaper to the outside of the completed joint straddling the external joint recess. Pour a grout mix consisting of Portland cement and sand in proportions recommended by the pipe manufacturer to completely fill the external joint recess. In lieu of the joint diaper, may with written approval of the pipe manufacturer, use a polyurethane foam joint protector, with unhydrated Portland cement dispersed throughout the protector. The protector shall have the cross-sectional shape required for the type of joint being installed and shall be formed in a loop to fit the size of pipe on which it is to be used.
h. Point interior joint recess of all pipe 24-inches in diameter and larger with Portland cement/sand mortar mixed in proportions recommended by the pipe manufacturer. Strike off grout smooth with the interior face of the pipe. For pipes 20-inches in diameter and smaller which convey sewage or non-potable water, the interior surfaces of the steel joint ring shall be protected by a flexible mastic joint filler applied to the bell socket just prior to joining the pipe such that the mastic squeezes out to fill the internal joint recess.
i. Maintain a sufficient quantity of joint lubricant, gaskets, joint diapers and joint fillers at the site of the Work at all times.
j. Do not use gaskets which have been scored or otherwise damaged.

5. Steel Pipe Joints:
   a. Joints in steel pipe shall be butt welded, flanged, or threaded joints, except that flexible couplings, mechanical couplings, or flanged connections shall be provided where shown on the Drawings.
   b. Welding shall conform to the requirements of AWWA C 206. Pipe 36-inches in diameter and larger shall be welded both inside and outside of the pipe.
      1) Submit documentation that all welders have been qualified in accordance with ASME Boiler and Pressure Vessel Code Section IX or American Welding Society Structural Welding Code D1.1, Section

5, whichever is required. Submit current certificates for the ENGINEER'S review.

c. After welding, the joint and the surrounding damaged or uncoated area shall be coated with the same material and to the same thickness as the shop applied coating.

d. Additional Welding Requirements:

1) On pipe lines specified to be welded, all joints between sections of pipe and between pipe and fittings 2-inches and larger shall be electric arc welded, and all joints on pipe 1-1/2 inches and smaller shall be gas welded. Entire responsibility for the quality of the welding belongs to CONTRACTOR.

a) Conduct tests not only of the welding procedure used by his organization to ensure welds that will meet the required tests, but also of the welding operators to determine the ability of the operators to make sound welds under standard conditions.

b) Be thoroughly familiar with ANSI B31.1, and American Welding Society Standard B3.0.

c) Be capable of performing all welding operations required for construction and installation of the piping systems.

2) Qualification of Welders: Rules of procedure for qualification of all welders and general requirements for fusion welding shall conform with the applicable portions of ANSI B31.1 and American Welding Society Standard B3.0, and also as outlined below.

3) Examining Welder: Each welder shall be examined at the job site by CONTRACTOR in the presence of the ENGINEER to determine the ability of the welder to meet the qualifications required. Welders for piping shall be tested for all positions, including welds with the axis horizontal (not rolled) and with the axis vertical. Each welder shall be:

a) Allowed to weld only in the position in which the welder is qualified.

b) Required to identify the weld with the specific code marking signifying the name and number assigned.

4) Examination Results: ENGINEER shall be provided with a listing of names and corresponding code markings. Where a welder fails to meet the prescribed welding qualifications, that welder shall be retested and, if the welder fails the second test, the welder shall be disqualified for work on the project.

e. For threaded joints, use standard, right hand tapered full depth threads on steel piping and apply an approved joint compound to the male threads only, before installation. Remove all cuttings and foreign matter from the inside of the pipe. Thoroughly clean all pipe, fittings, valves, specials, and accessories before installing.

6. Thermoplastic Pipe Joints:

a. Solvent Cement Joints:

1) Bevel pipe ends and remove all burrs before making joints. Clean both pipe and fittings thoroughly. Do not attempt to make solvent cement joints if temperature is below 40°F nor in wet conditions.
2) Use solvent cement supplied or recommended by the pipe manufacturer.
3) Apply joint primer and solvent cement and assemble joints in strict accordance with the recommendations and instructions of the manufacturer of the joint materials and the pipe manufacturer.
4) Observe safety precautions with the use of joint primers and solvent cements. Allow air to circulate freely through pipelines to permit solvent vapors to escape. Slowly admit water when flushing or filling pipelines to prevent compression of gases within pipes.

b. Threaded Joints:
1) Cut pipe square and smooth and remove burrs or raised edges with a knife or file. Hold pipe firmly in a pipe vise. Protect pipe at the point of grip by inserting a rubber sheet or other material between the pipe and vise. Thread pipe in accordance with the pipe manufacturer's recommendations. Brush threads clean of chips and ribbons. Then starting with the second full thread, and continuing over the thread length, wrap Teflon thread tape in the direction of the threads. Overlap each wrap by one half the width of the tape. Screw the fitting or coupling onto the pipe and tighten by hand. Using a strap wrench only, further tighten the connection an additional one to two threads past tightness.

7. Copper Tubing Joints:
a. Assemble copper tubing with soldered joints. Solder shall be 95-5 tin-antimony conforming to ASTM B32.
b. Ream or file pipe to remove burrs.
c. Clean and polish contact surfaces of joints.
d. Apply flux to both male and female ends.
e. Insert end of tube into full depth of fitting socket.
f. Heat joint evenly.
g. Form continuous solder bead around entire circumference of joint.
h. Runs shall contain unions at connections to equipment and at reasonable distances along the lengths of runs to permit convenient disassembly of piping and removal of equipment.

E. Installing Valves and Accessories:
1. Provide supports for large valves, flow meters and other heavy items as shown on the Drawings or required.
2. Install floor stands as shown on the Drawings and as recommended by the manufacturer.
3. Provide lateral restraints for extension bonnets and extension stems as shown on the Drawings and as recommended by the manufacturer.
4. Provide steel sleeves where operating stems pass through floor. Extend sleeves 2-inches above floor.

5. Position valve operators as shown on the Drawings. When the position is not shown on the Drawings, install the valve so that it can be conveniently operated and as approved by ENGINEER. Avoid placing operators at angles to the floors or walls.
6. Position flow measuring devices in pipe lines so that they have the amount of straight upstream and down stream runs recommended by the manufacturer, unless specific location dimensions are shown on the Drawings. Position swing check valves so that they do not conflict with the discs of butterfly valves.

F. Unions:
1. Install dielectric unions wherever dissimilar metals are connected, except for bronze or brass valves in ferrous piping.
2. Provide a union downstream of each valve with screwed connections.
3. Provide screwed or flanged unions at each piece of equipment, where shown on the Drawings, and where necessary to install or dismantle piping.

G. Eccentric Reducers: Use eccentric reducers where shown on the Drawings and where air or water pockets would otherwise occur in mains because of a reduction in pipe size.

H. Transitions from One Type of Pipe to Another:
1. Provide all necessary adapters, specials and connection pieces required when connecting different types and sizes of pipe or connecting pipe made by different manufacturers.

I. Taking Existing Pipelines Out of Service:
1. Do not take pipelines out of service, unless specifically named below or approved by ENGINEER.
   a. Refer to Section 01143, Coordination with OWNER'S Operations.
2. Notify ENGINEER at least 48 hours prior to taking pipeline out of service.

J. Work on Existing Pipelines:
1. Cut or tap pipes as shown on the Drawings or required with machines specifically designed for this Work.
2. Install temporary plugs to keep out all dirt, water and debris.
3. Provide all necessary adapters, fittings, pipe and appurtenances required.

3.2 THRUST RESTRAINT

A. Provide thrust restraint on all pressure piping systems and where otherwise shown on the Drawings or specified.

B. Thrust restraint shall be accomplished by means of restrained pipe joints. Thrust restraints shall be designed for the axial thrust exerted by the test pressure specified in Section 15050, Piping Systems.

C. Restrained Pipe Joints:
   1. Pipe joints shall be restrained by means suitable for the type of pipe being installed.
      a. Restrain concrete pipe joints utilizing welded joints.
      b. Restrain ductile iron mechanical joint pipe utilizing tie rods and clamps or proprietary restrained joint system conforming to the requirements of Section 15101, Ductile Iron Pipe.
      c. Restrain ductile iron pipe connected by flexible couplings or flanged coupling adapters by harnessing across the coupling or adapter using tie rods or extended bolts connecting between flanges.
      d. Steel pipe shall have butt-welded joints, flanged joints, or flexible or mechanical coupling connectors. Provide tie rods connected to ears welded to the steel pipe for restraint at all flexible coupling connectors.

3.3 PAINTING

A. Field painting shall conform to the requirements of Section 09900, Painting.

3.4 TESTING OF PIPING

A. General:
   1. Test all piping as specified below, unless otherwise authorized by ENGINEER.
   2. Notify ENGINEER 48 hours in advance of testing.
   3. Provide all testing apparatus including pumps, hoses, gages, and fittings.
   4. Pipelines shall hold the specified test pressure for two hours.
   5. Repair and retest pipelines which fail to hold specified test pressures or which exceed the allowable leakage rate.
   6. Test pressures required are at the lowest elevation of the pipeline section being tested, unless otherwise specified.
   7. Follow special test procedures below for gaseous chemical and liquid chlorine lines.
   8. Conduct all tests in the presence of the ENGINEER. Repeat tests in the presence of local authorities having jurisdiction, if required.

B. Schedule of Pipeline Tests:
   1. Test piping at the test pressure specified in Section 15050, Piping Systems.
   2. For piping not included in Section 15050, Piping Systems, the ENGINEER will notify CONTRACTOR, in writing, of the test pressure to be utilized.

C. Pressure Test Procedure:
   1. Ensure that all supports and restraint protection are securely in place.
   2. Fill section to be tested slowly with water and expel all air. Install cocks, if necessary, to ensure removal of air.
   3. Test only one section of pipe at a time.
   4. Apply specified test pressure required for two hours and observe pressure gage. Check carefully for leaks while test pressure is being maintained.

D. Leakage Testing:
   1. Conduct leakage test after satisfactory completion of pressure test.
   2. Allow concrete pipe to stand full of water at least 12 hours prior to starting leakage test.
   3. Allowable Leakage Rates (gallons per hour per 1000 feet per inch diameter):
      a. Concrete Pressure Pipe: 0.0.
      b. Copper, Steel, Ductile Iron, Thermoplastic, and all Other Piping: 0.0.
      c. Ductile Iron Pipe with Mechanical Joints: 0.0.
   4. Leakage Test Procedure:
      a. Examine exposed pipe, joints, fittings and valves. Repair visible leakage or replace the defective pipe, fitting or valve.
      b. Refill the line under test to reach the required test pressure.
      c. Provide a test container filled with a known quantity of water at the start of the test. Attach the test pump suction to the test container.
      d. Pump water from the test container into the line with the test pump to hold the specified test pressure for the test period. Water remaining in the container shall be measured and the amount used during the test shall be recorded on the test report.
      e. Perform all repair, replacement, and retesting required because of failure to meet testing requirements.
      f. Leakage shall be less than rate specified above.

E. Additional Procedures for Gaseous Chemical Piping:
   1. Purge piping completely with dry compressed nitrogen or air after pressure and leakage tests have been satisfactorily completed.
   2. Fill pipeline with dry air or nitrogen and pressurize to 50 psi.
   3. Test all joints with a soapy water solution.
   4. Demonstrate that vacuum lines are completely tight under a vacuum of 25-inches of mercury.

F. Test Procedures for Chlorine Piping: Conform to all requirements of the Chlorine Manual and Pamphlet No. 6 of the Chlorine Institute.
   1. Dry the piping with steam and dry air, and then purge piping completely with dry compressed nitrogen or air after pressure and leakage tests have been satisfactorily completed.
   2. Fill pipeline with dry air or nitrogen and test as described in the Chlorine Manual.
   3. Test all joints with a soapy water solution.

3.5 TESTING OF DRAINAGE PIPING

A. General:
   1. Test all drainage piping installed under this Section.
   2. Provide all testing apparatus required.
   3. Notify ENGINEER 48 hours in advance of test.

4. Conduct all tests in presence of ENGINEER.

B. Procedures:
   1. Perform test on entire system or on individual sections as approved by ENGINEER.
   2. Completely seal all openings except highest opening in system or section to be tested.
   3. Fill with water completely and test with at least ten feet of water above highest point.
   4. Allow water to stand in system for at least 15 minutes. Inspect for leaks and repair all leaks found. Retest repaired sections.

3.6 CLEANING AND DISINFECTION

A. Cleaning:
   1. Thoroughly clean all piping and flush prior to placing in service in a manner approved by ENGINEER.
   2. Piping 24-inches in diameter and larger shall be inspected from inside and all debris, dirt and foreign matter removed.
   3. If piping which requires disinfection has not been kept clean during storage or installation, swab each section individually with a five percent hypochlorite solution, to ensure clean piping.

B. Disinfection:
   1. Disinfect all potable and finished water piping.
   2. A suggested procedure for accomplishing disinfection is specified below. Other procedures will be considered for approval by the ENGINEER.
      a. Thoroughly flush piping prior to disinfection with water. For pipelines 24-inches in diameter and larger, pipelines shall be manually cleaned, carefully removing all sweeping, dirt and debris prior to disinfection.
      b. Conform to procedures described in AWWA C 651. Continuous feed method of disinfecting shall be used, unless alternative methods are acceptable to ENGINEER.
   3. Water for initial flushing, testing and chlorination will be furnished by OWNER. Provide all temporary piping, hose, valves, appurtenances and services required. Cost of water required for redisinfection will be paid by CONTRACTOR to OWNER at OWNER'S standard rates.
   4. Chlorine will be supplied by CONTRACTOR.
   5. Bacteriologic tests will be performed by OWNER. A certified laboratory report will be available to CONTRACTOR, if requested.
   6. Chlorine concentration in the water entering the piping shall be between 50 and 100 parts per million, such that a minimum residual concentration of 25 mg/l will be left after a 24-hour retention period. Care shall be taken to ensure disinfection of the piping in all its parts. The operation shall be repeated as required to provide complete disinfection.

7. After the required retention period, the heavily chlorinated water shall be flushed to approved drain location, unless otherwise directed by the ENGINEER.

3.7 DISPOSAL OF WATER

A. Provide suitable means for disposal of test and flushing water so that no damage results to facilities or waterways.

B. Means of disposal of test and flushing water shall be subject to the approval of ENGINEER, local governing authorities and regulatory agencies.

C. Responsibility for any damages caused by the water disposal operations belongs to CONTRACTOR.

3.8 IDENTIFICATION OF PIPING

A. Pipe Identification Markers and Arrows:
   1. Product and Manufacturer: Provide one of the following:
      a. Brady B-500 vinyl cloth self sticking arrows and markers except on insulated pipe. Brady B-350 perma-code film self sticking arrows and markers on pipe insulation.
      b. Equivalent products as made by Seton Name Plate Corporation.
      c. Or equal.
   2. Install markers and arrows at following locations:
      a. At intervals not exceeding 50 feet along continuous runs of pipe.
      b. Wherever pipes pass through walls, floors or panels.
      c. At each valve or equipment connection.
      d. At each branch where it connects to a main line.

+ + END OF SECTION + +

SECTION 15061

PIPE HANGERS AND SUPPORTS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment, and incidentals as shown on the Drawings, specified and required to design, furnish, and install all hangers, supports and appurtenances required to complete the Work.

1.2 QUALITY ASSURANCE

A. Each type of pipe hanger, pipe guide, anchor or support shall be the product of one manufacturer.

B. Reference Standards: Comply with applicable provisions and recommendations of the following, except as otherwise shown or specified.
   1. Manufacturers Standardization Society of the Valve and Fittings Industry:
      a. MSS SP-58, Pipe Hangers and Supports - Materials and Design.
      b. MSS SP-69, Pipe Hangers and Supports - Selection and Application.
   2. Federal Specification, FS A-A-1192, Hangers and Support, Pipe.
   3. ASTM A575, Specification for Steel Bars, Carbon, Merchant Quality, M-Grades.
   4. Underwriters' Laboratories, Inc., Standard UL-203-Pipe Hanger Equipment.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Detailed drawings showing all hangers, supports and expansion compensation for each piping system specified. Shop Drawings shall show location, installation, material, loads and forces, and deflection of all hangers and supports, including expansion and contraction. Each pipe system shall be analyzed for all loads and forces on the hangers and supports, and their reaction forces to the structure to which they are fastened.
   2. Submit and coordinate these with Shop Drawings required for all piping systems, valves and appurtenances.
   3. Refer to and comply with the requirements of Section 01332, Shop Drawing Procedures.

B. Product Information: Submit manufacturers' catalogs, literature, and engineering data on all hangers and supports. Load ratings, materials and installation shall be consistent with the recommendations of the MSS SP-58, MSS SP-69 and Federal Specification A-A-1192.

1.4 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to the site to ensure uninterrupted progress of the Work. Deliver pipe hanger inserts and anchorage devices which are to be embedded in cast-in-place concrete in ample time to prevent delay of the Work. Refer to and comply with the requirements of Section 01651, Transportation and Handling of Materials and Equipment.

B. All boxes, crates and packages shall be inspected by CONTRACTOR upon delivery to the site. Notify ENGINEER of any loss or damage exists to equipment or components. Replace loss and repair damage to new condition in accordance with manufacturer's instructions.

C. Store materials to permit easy access for inspection and identification. Keep all materials off ground, using pallets, platforms or other supports. Protect steel members and packaged materials from corrosion and deterioration. Refer to and comply with the requirements of Section 01661, Storage of Materials and Equipment.

PART 2 - PRODUCTS

2.1 GENERAL

A. Hangers and supports shall meet with the following requirements:
   1. Standard and fabricated hangers and supports shall be furnished complete with necessary inserts, bolts, nuts, rods, washers, and other accessories.
   2. Generally, run piping in groups where practicable and parallel to building wall. Provide minimum clearance of 1-inch between pipe and other work.
   3. Install hangers or supports at all locations where pipe changes direction.
   4. All hangers and supports shall be capable of adjustment after placement of piping.
   5. Different types of hangers or supports shall be kept to a minimum.
   6. All suspended or supported ductile iron pipe shall have a hanger or support adjacent to each hub.
   7. Support vertical piping at each floor and between floors by stays or braces to prevent rattling and vibration.
   8. Hanger rods shall be straight and vertical. Chain, wire, strap or perforated bar hangers shall not be used. Hangers shall not be suspended from piping.
   9. Maximum support spacing, unless otherwise shown on the Drawings or approved shall be as follows:

Pipe Size (inches)	Maximum Pipe Span [1] (feet)			
	Steel	Copper	Plastic [2]	Cast/Ductile Iron [4]
3/8 to 3/4	5	6	Cont. [3]	-
1	6	6	5	-
1-1/4	6	6	5	-
1-1/2	6	6	5	-
2	10	10	5	-
2-1/2	10	10	5	-
3	10	10	5	-
4	12	12	5	12 feet for pressure pipe
6	12	12	5	
8	12	12	5	
10	12	-	5	
12	12	-	10	
14	12	-	-	
16	12	-	-	
18	12	-	-	
20	12	-	-	10 feet for soil pipe
24	12	-	-	

[1] *Pipe shall not have pockets formed in the span due to sagging of the pipe between supports caused by the weight of the pipe, medium in the pipe, insulation, valves and fittings.*

[2] *Span shown is for Schedule 80 CPVC pipe at 100°F. Spans for other plastics, other CPVC pipe Schedules and pipes at higher temperatures shall be shortened in accordance with the pipe manufacturer's recommendations.*

[3] *Continuous means pipe shall be in unistrut or similar channel.*

[4] *Pipe hanger and support selection shall be as shown on the Drawings and this Section.*

10. Maximum support spacing, unless otherwise shown on the Drawings, for plastic pipe at ambient temperature shall be one-half of the values specified for steel pipe.
11. Plastic pipe at temperature greater than 130°F shall be continuously supported in a metal cradle or tray.
12. Where proper hanger or support spacing does not correspond with joist or rib spacing, structural steel channels may be attached to joists or ribs and pipes suspended therefrom.
13. Prevent contact between dissimilar metals when supporting copper tubing, by use of copper plated, rubber or vinyl coated, or stainless steel hangers or supports.

14. Isolate thin walled stainless steel piping from carbon steel by use of plastic coated hangers or supports or by taping at points of contact with PVC or vinyl.
15. Supports and hangers shall be of a material that is compatible with the fluid being conveyed in such pipe being supported.
16. Anchors for pipe support systems shall be compatible or protected by a coating system which is compatible with the fluid being conveyed in such pipe being supported.
17. Pipe stands shall be a minimum of 3-inches in diameter and the discharge header shall have hold-down straps. Supports shall have a minimum of 2-inch dry packed grout under 100 percent of the support plate and no voids are allowed. The grout shall be struck off tapered on all sides.
18. Wherever there is a removable, serviceable piece of equipment within the piping system, there must be a support on either side in such a way to allow the equipment to be removed without disturbing the pipe alignment.

B. Expansion compensation shall be designed for individual exposed piping systems with the following Design Criteria:
   1. $\Delta L = L \times \Delta T \times \alpha$
      a. Where ΔL = pipe length change (in.)
      b. L = pipe length between anchors (in.)
      c. ΔT = 100 (F)
      d. α = coefficient of thermal expansion (in./in./F)
   2. Expansion compensation shall be designed as an integral part of the piping hanger, support and anchorage system.
   3. Expansion compensation shall be achieved via expansion joints specified in Section 15120, Piping Specialties and Accessories.

2.2 HANGERS AND SUPPORTS

A. Hangers, supports, pipe guides and anchors where shown shall be in accordance with the Drawings. Hangers and supports not shown shall be in accordance with MSS SP-58.

B. Manufacturers:
   1. ITT Grinnell Company.
   2. Elcan
   3. B-Line.
   4. Unistrut Corporation

C. Chemical Piping and Nocardia Spray System:
   1. All pipe supports and fasteners shall be glass fiber-reinforced plastic with a flame spread rating of 25, in accordance with ASTM E 84.
   2. Materials shall be manufactured by either the pultrusion or extrusion process.

3. All pipe supports shall have a surface veil over 100 percent of the surface which, along with a filler system, shall protect against degradation from ultra-violet light.
4. All fasteners shall be manufactured from long glass fiber-reinforced polyurethane to ensure strength and corrosion resistance.
5. All-thread rods shall be made from vinylester resin.
6. Product and Manufacturer: Provide one of the following:
   a. Unistrut Company.
   b. Or equal.

2.3 ACCESSORIES

A. Hanger rods shall be made from ASTM A575, with square head nut on top and running thread on bottom end.

B. Concrete Inserts:
   1. Concrete inserts shall be MSS SP-58 malleable Type 18.
   1. Concrete inserts shall be of the continuous type capable of supporting 50 pounds per foot of insert as shown on the Drawings.
   2. Product and Manufacturer: Provide one of the following:
      a. Unistrut Corporation.
      b. Elcan Metal Products.
      c. ITT Grinnell.
      d. B-Line.

C. Inserts for Pipe Insulation:
   1. Insulated pipe, larger than 1-1/2-inches in diameter, shall be supported by a rigid insert to protect the insulation. A steel metal saddle of sufficient gage to carry the weight of the pipe and its fluid without deforming shall extend 2-inches minimum on each side of the rigid insert. The joints between insert and insulation shall be sealed before saddle is installed. Sizes up to 6-inches IPS shall be MSS SP-58 Type 40 and for sizes over 10-inches shall be MSS SP-58 Type 39.

D. Brackets:
   1. Brackets for wall mounting shall be MSS SP-58.

E. Pipe Roll:
   1. To provide for pipe expansion, pipe shall be supported on adjustable malleable or steel pipe rolls.

F. Fabricated Pipe Rack:
   1. Pipes shall be supported and anchored to the fabricated pipe rack as shown on the Drawings. Clamps, rollers, and supports for piping shall conform to the general requirements of MSS SP-69.

2.4 PAINTING

A. Clean and shop prime ferrous metal surfaces in the shop in accordance with the requirements of Section 09900, Painting.

B. Field painting shall conform to the requirements of Section 09900, Painting.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Locate hangers, supports, and accessories to support piping, valves, and at all concentrated loads.

B. Locate hangers, supports, and accessories within maximum span lengths specified to support continuous pipeline runs unaffected by concentrated loadings.

C. Locate hanger, supports to prevent vibration or swaying and to provide for expansion and contraction.
   1. Temperature differential as specified in this Section.
   2. Support piping independently so that equipment is not stressed by piping weight or expansion/contraction.
   3. For Uninsulated Copper Pipe or Tubing: Clamps and supports, electroplated copper finish. All tubing layout and connections shall be as approved by the manufacturer of the equipment.
   4. Uncoated Hangers, Rods and Supports: Dip in zinc chromate primer before installation.
   5. Maximum spacing for horizontal piping:
      a. Refer to table in Paragraph 2.1.A.9, above.
      b. Additional supports at:
         1) Change in direction.
         2) Branch piping and runouts over five feet.
         3) Concentrated loads due to valves, strainers and other similar items.
      c. Maximum support spacing for plastic pipe at ambient temperature shall conform to the requirements of the table located in Paragraph 2.1.A.9., above, unless otherwise shown on the Drawings.
   6. Hanger types for horizontal piping, except as noted and shown on the Drawings:
      a. Forged steel adjustable clevis type, rod support for all service.
      b. Slide Bases:
         1) Pipe stand, brackets, trapeze or other equivalent structural support.
         2) For piping 2-inches or larger.
      c. For pipe and covering provide:
         1) Saddles for rollers or slide bases.
         2) Protective shields or saddles for all other types of supports.

d. Threaded Steel Rods:
   1) Two inch vertical adjustment with two nuts at each end for positioning and locking.
   2) Size hanger rods according to the schedule below, unless otherwise noted on the Drawings:

Nominal Pipe (Inches)	Rod Diameter (Inches)
2 and less	3/8
2-1/2 to 3-1/2	1/2
4	5/8
6	3/4
8 through 12	7/8
14 through 18	1
20 through 30	1-1/4

   3) For Double Rod Hangers: One size smaller than above.
   4) Connection to Structure for Piping to 2-Inches: Concrete inserts in shear into sides of beams.
   5) Connection to Structure for Piping 2-1/2 Inches or Larger: Concrete inserts, beam clamps or suitable bridging.

7. Vertical Piping:
   a. Base Support: Base elbow or welded equivalent.
      1) Bearing plate on structural support.
   b. Guides not to exceed:
      1) Twenty five feet for piping to 2-inches.
      2) Thirty six feet for piping 2-1/2-inches or larger.
      3) Ten feet for chlorination piping.
   c. Top Support:
      1) Special hanger or saddle in horizontal connection.
      2) Provisions for expansion/contraction.
   d. Intermediate Supports: Steel pipe clamp at floor.
      1) Bolted and welded to pipe.
      2) Extension ends bearing on structural steel or bearing plates.
   e. For Multiple Pipes: Coordinate guides, bearing plates and accessory steel.
8. Insulated Piping:
   a. Horizontal Pipe Shields at Supports:
      1) Minimum 120 degree arc.
      2) Length equal to diameter of insulation, 12-inch minimum.
      3) To 6-Inch Pipe Size: No. 18 USSG stainless steel.
   b. Vertical Pipe Shields at Guides:
      1) Full 360 degree arc, securely banded.
      2) Length equal to diameter of insulation, 12-inch minimum.
      3) To 6-Inch Pipe Size: No. 18 USSG stainless steel.

D. Install items to be embedded before concrete placement.

E. Fasten embedded items securely to prevent movement during concrete placement.

F. Install hangers and support units on piping systems in accordance with manufacturer's recommendations and instructions.

G. Adjust hangers, supports, pipe guides and anchors and place grout for concrete supports to bring pipelines to specified elevations.

H. Bring all pipe systems up to operating pressures and temperatures. Cycle systems to duplicate operating conditions. Correct all support malfunctions.

+ + END OF SECTION + +

SECTION 15071

VIBRATION ISOLATION

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish and install vibration isolation for all items of equipment listed complete with all appurtenances.

B. General:
   1. Vibration control shall be achieved by use of approved vibration eliminators installed as directed by the manufacturer of the eliminators.
   2. All Work shall operate under all conditions of load without objectionable sound or vibration.
   3. In the case of moving machinery, sound or vibration noticeable outside the room in which it is installed or annoyingly noticeable inside its own room, will be considered objectionable.
   4. Objectionable sound or vibration will be corrected by CONTRACTOR in a manner approved by ENGINEER and at no additional cost to the OWNER.

1.2 QUALITY ASSURANCE

A. Manufacturer's Qualifications:
   1. Manufacturer shall have a minimum of five years experience of producing substantially similar equipment and shall be able to show evidence of at least five installations in satisfactory operation for at least five years.

B. Requirements of Regulatory Agencies: Comply with the applicable provisions of regulatory agencies below and others having jurisdiction:
   1. Phoenix Building Code.
   2. Phoenix Mechanical Code.

C. Design Criteria:
   1. Vibration isolators shall be selected for uniform state deflections according to distribution of weight.
   2. Selections shall be based on lowest rotational speed as disturbing frequency.
   3. Total rated capacity of isolators shall be at least 150 percent the weight of equipment supported.

D. Reference Standards: Comply with applicable provisions and recommendations of the following, except as shown or specified.
   1. ASHRAE.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Manufacturer's literature, illustrations, specifications, and engineering data to include the following:
      a. Isolation mounting deflections.
      b. Spring diameters.
      c. Compressed spring height at rated load.
      d. Solid spring height.
      e. Equipment operating speed.
      f. Other material and equipment requested by ENGINEER.
   2. Drawings showing fabrication methods, assembly, installation details and accessories.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Mark all eliminators with identification as to item of equipment and exact location.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Product and Manufacturer: Provide one of the following:
   1. Mason Industries.
   2. Vibration Eliminator Company.
   3. Or equal.

2.2 DOUBLE DEFLECTION MOUNTINGS

A. Material: Neoprene.

B. Minimum Static Deflection: 0.35-inch.

C. All metal surfaces neoprene coated.

D. Friction pads on top and bottom.

E. Steel rails shall compensate for overhang.

F. Provide bolt holes at proper locations.

2.3 SPRING HANGERS

A. Type: Spring isolators, laterally unrestrained.

B. Efficiency: 95 percent at rated load.

C. Construction:
   1. Designed so that ratio of horizontal to vertical spring constants is between one and two.
   2. Steel spring with 0.3-inch deflection neoprene element.
   3. Neoprene element shall have rod isolation bushing.
   4. Hanger shall permit rod to swing through 30 degree arc before contacting metal.
   5. Spring shall have addition travel to solid of 50 percent of rated deflection.

2.4 UNHOUSED SPRING MOUNTINGS

A. Type: Spring isolator, free standing, laterally stable unhoused.

B. Efficiency: 95 percent of rated load.

C. Construction:
   1. Baseplate with 1/4-inch acoustical friction pad between baseplate and support.
   2. Leveling bolts rigidly bolted to the equipment.
   3. Spring diameter 0.8 of the compressed spring height at rated load.
   4. Minimum spring deflection before becoming solid shall be at least 50 percent greater than the specified minimum deflection.

2.5 HOUSED SPRING MOUNTINGS

A. Type: Spring isolator, free standing, laterally stable with housing.

B. Efficiency: 95 percent at rated load.

C. Construction:
   1. Housing: Shall include vertical limit stops.
   2. Clearance: Maintain 1/2-inch clearance around restraining bolts and between housing and spring.
   3. Weatherproofing: Hot dip galvanized for outdoor use.
   4. Baseplate with 1/4-inch acoustical friction pad between baseplate and support.
   5. Leveling bolts rigidly bolted to the equipment.
   6. Spring diameter 0.8 of the compressed spring height at rated load.

7. Minimum spring deflection before becoming solid shall be at least 50 percent greater than the specified minimum deflection.

2.6 ISOLATION BASES

A. Type: Integral structural steel frame bases, welded to height saving brackets.

B. Equipment Bases: Rectangular, except pump bases which may be "T" or "L" shaped.

C. Depth: Perimeter members shall be beams with a minimum depth equal to a minimum 1/10th of the longest base dimension and maximum depth of 14-inches.

D. Brackets: Height saving type, provide minimum of 1-inch base clearance.

E. Isolators: As specified in Article 2.4, above.

2.7 ISOLATION RAILS

A. Type: Steel members welded to height saving brackets for equipment with legs or brackets.

B. Members shall be sufficiently rigid to prevent strains in equipment.

C. Isolators: As specified in Article 2.4, above.

2.8 CURB MOUNTED BASES

A. Type: Curb mounted aluminum base.

B. Base shall fit standard curb and match underside of the isolated equipment.

C. Seals: Wind and water seals that do not interfere with spring action.

D. Resist wind forces and aging.

E. Material: Extruded aluminum and neoprene connections.

F. Springs: Cadmium plated, 1-inch minimum deflection with positive spring retainers.

G. Corners: Welded, two neoprene safety stops each side.

PART 3 - EXECUTION

3.1 INSPECTION

A. Inspect anchor bolts for proper locations.

3.2 INSTALLATION

A. Install in accordance with the manufacturer's recommendations and instructions.

3.3 CLEANING

A. Remove foreign objects which might bridge vibration isolators.

3.4 SCHEDULES

A. Use types of isolators for equipment specified below, unless otherwise specified.

	Equipment	Type
1.	Suspended inline duct fans, piping 50 feet on suction and discharge side of pumps:	Spring hanger
2.	HVAC units:	Isolation rails
3.	Small hot water circulating pumps, exhaust fans (floor mounted):	Double Deflection Mounting
4.	Rooftop packaged air conditioning unit:	Curb mounted base

B. Concrete inertia bases for fans shall be provided with the following thicknesses of concrete:

	Motor Horsepower			
Wheel Dia.	Fract.-30	40-50	60-100	125-150
36-inch & Smaller	6-inch (Min.)	6-inch (Min.)	8-inch (Min.)	10-inch (Min.)
40-inch to 66-inch:	6-inch (Min.)	8-inch (Min.)	10-inch (Min.)	10-inch (Min.)
73-inch to 89-inch:	8-inch (Min.)	10-inch (Min.)	12-inch (Min.)	12-inch (Min.)

C. Concrete inertia base thickness for pumps shall be in accordance with the following schedule:

Motor Size	Inertia Block Thickness
5 HP to 15 HP	6-inches (Minimum)
20 HP to 50 HP	8-inches (Minimum)
60 HP to 100 HP	10-inches (Minimum)
100 HP and over	12-inches (Minimum)

+ + END OF SECTION + +

SECTION 15101

DUCTILE IRON PIPE

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
1. Provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish ductile iron pipe and fittings.
2. The extent of the piping is shown on the Drawings and in Section 15050, Piping Systems.

1.2 QUALITY ASSURANCE

A. Qualifications:
1. Manufacturer shall have a minimum of five years of experience producing ductile iron pipe and fittings, and shall be able to show evidence of at least five installations in satisfactory operation of similar diameters, lengths, and pipe class required for the Work.
2. All ductile iron pressure water pipe shall be furnished by a single manufacturer and fully manufactured in the USA, including casting, testing, and all applicable linings and coatings. The supplier shall be responsible for the provisions of all test requirements specified in AWWA C151 as applicable. In addition, all ductile iron pressure water pipe to be installed under this Contract may be inspected at the plant for compliance with these specifications by an independent testing laboratory provided by the OWNER. The CONTRACTOR shall require the manufacturer's cooperation in these inspections. The cost of plant inspection of all pipe approved for this Contract, will be borne by the OWNER.

B. Reference Standards: Comply with applicable provisions and recommendations of the following, except as otherwise shown or specified.
1. AWWA C104, Cement-Mortar Lining for Ductile Iron Pipe and Fittings.
2. AWWA C110, Ductile Iron and Gray-Iron Fittings.
3. AWWA C111, Rubber-Gasket Joints for Ductile Iron Pressure Pipe and Fittings.
4. AWWA C115, Flanged Ductile Iron Pipe with Ductile-Iron or Grey-Iron Threaded Flanges.
5. AWWA C150, Thickness Design of Ductile Iron Pipe.
6. AWWA C151, Ductile Iron Pipe, Centrifugally Cast.
7. AWWA C153, Ductile-Iron Compact Fittings for Water Service.
8. AWWA C600, Installation of Ductile Iron Water Mains and Their Appurtenances.
9. AWWA C606, Grooved and Shouldered Joints.
10. ANSI/ASME B16.1, Grey Iron Pipe Flanges and Flanged Fittings.
11. ANSI/ASME B18.2.1, Square, Hex, Heavy Hex and Askew Head Bolts and Hex, Heavy Hex, Hex Flange, Lobed Head and Lax Screws (Inch Series).

12. ANSI/ASME B18.2.2, Nuts for General Applications: Machine Screw Nuts, Hex, Square, Hex Flange, and Coupling Nuts (Inch Series).
13. ASTM A307, Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
14. ASTM A354, Standard Specification for Quenched and Tempered Alloy Steel Bolts, Studs and Other Externally Threaded Fasteners.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Submit detailed drawings and data on pipe, fittings, gaskets and appurtenances as required. Refer to and comply with the requirements of Section 15051, Buried Piping Installation, Section 15052, Exposed Piping Installation, Section 15121, Wall Pipes, Floor Pipes and Pipe Sleeves, and Section 15061, Pipe Hangers and Supports.
   2. Within 14 days of the Date of Agreement, submit the name of the pipe manufacturer and a list of materials to be furnished by said manufacturer. Also, include information on local representative for manufacturer, if product is sold through a distributor.
   3. Shop Drawings shall include piping layouts and schedules. Drawings shall include dimensioning, joint details (including standard and restrained joint details) indicating all pertinent dimensions and manufacturing tolerances, methods and location of supports, anchorage, gasket material, grade of material, and all other pertinent technical information for all items to be furnished.
   4. Submit manufacturer's catalog data and descriptive literature for all material items listed below. Show dimensions and materials of construction by specification reference and grade where applicable.
      a. Polyethylene film for encasement of ductile iron.
      b. Wire.
      c. Exothermic weld kit.
      d. Weld caps.
      e. Weld coating.
   5. Qualifications of the contractor’s Corrosion Engineer and Corrosion Technician.

B. Certificates: Submit certificates of compliance with referenced standards.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Deliver materials to the site to ensure uninterrupted progress of the Work.

B. Handle all pipe, fittings, specials and accessories carefully with approved handling devices. Do not drop or roll material off trucks. Do not otherwise drop, roll or skid piping.

C. Store pipes and fittings on heavy wood blocking or platforms so they are not in contact with the ground.

D. Unload pipe, fittings and specials opposite to or as close to the place where they are to be installed as is practical to avoid unnecessary handling. Keep pipe interiors completely free from dirt and foreign matter.

E. Inspect delivered pipe for cracked, gouged, chipped, dented or otherwise damaged material and immediately remove from site.

F. Any pipe or fitting showing a crack or which has received a blow that may have caused an incident fracture, even though no such fracture can be seen, shall be marked as rejected and removed at once from the work.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General:
1. Joints shall be as specified in Section 15050, Piping Systems. If not specified, provide flanged joints for exposed piping and push-on or mechanical joints for buried piping. Couplings shall be provided on pipe with plain or grooved ends where shown on the Drawings or where approved by ENGINEER. Joints for piping located in vaults and structures shall be flanged unless mechanical clamp-type couplings or flange adapters are shown on the Drawings.
2. Ductile iron pipe shall be designed, manufactured, tested, inspected, and marked in accordance with the provisions of this Specification and AWWA C151 except as modified herein.
3. All ductile iron pipe 16-inches and larger shall have cathodic protection. Pipelines less than 16-inches shall have cathodic protection where called for in the plans and specifications.

B. Ductile Iron Pipe and Fittings:
1. Flanged Pipe: Fabricate in accordance with requirements of AWWA C115.
   a. Thickness: Wall thickness shall be minimum Class 53 except where the specified pressures requires heavier pipe.

2. Non-Flanged Pipe: Conform to AWWA C151 for material, pressure, dimensions, tolerances, tests, markings and other requirements.
   a. Pressure: Pipe shall be designed to meet the testing requirements of Paragraph 3.1.C. If not shown on the Drawings, use Pressure Class 350.
   b. Minimum Thickness: Class 53 unless specifically noted otherwise.

3. Joints:
   a. Flanged Joints: Conform to AWWA C110, C115 and C153 capable of meeting, working and test pressure specified in Paragraph 3.1.C.
      1) Gaskets: High temperature resistant sealing compounds (Loctite PST 592) or equivalent with Dimethacrylate ester base and Teflon can be used.

a) Gaskets: Unless otherwise specified, gasket stock shall be a synthetic rubber, 1/8-inch thick, full face, compound in which the elastomer is nitrile or neoprene. The compound shall contain not less than 50 percent by volume nitrile or neoprene and shall be free from factice, reclaimed rubber and other deleterious substances. Gaskets shall comply with AWWA C111 for push-on and mechanical joints with AWWA C606 for grooved end joints.

2) Bolts and Nuts: Conform to ANSI B18.2.1 and ANSI B18.2.2, respectively. Exposed and buried bolts and nuts shall be ASTM A307, Grade B. Buried bolts and nuts not encased in polyethylene shall be mortar coated to a minimum thickness of 1-inch or alternately coated with a petroleum based mastic and wrapping tape system Denso Paste primer and Densyl Tape finish as manufactured by Denso, or approved equal. Submerged bolts and nuts shall be Type 316 stainless steel.

b. Mechanical Joints: Conform to AWWA C110, AWWA C111 and C153.
   1) Glands: Ductile iron.
   2) Gaskets: Plain Tip.
   3) Bolts and Nuts: Conform to ANSI B18.2.1 and ANSI B18.2.2, respectively. Bolts and nuts shall be ASTM A307, Grade B. Buried bolts and nuts not encased in polyethylene shall be mortar coated to a minimum thickness of 1-inch or alternately coated with a petroleum based mastic and wrapping tape system Denso Paste primer and Densyl Tape finish as manufactured by Denso, or approved equal.

c. Push-On Joints: Conform to AWWA C111.
   1) Gaskets: Molded rubber.
   2) Strips: Each plain end shall be painted with a circular stripe to provide a guide for visual check that joint is properly assembled.

d. Grooved End Joints: Conform to AWWA C606.
   1) Gaskets: Flush seal type designed for ductile iron.
   2) Bolts and nuts: As specified for flanged joints.
   3) Unless otherwise specified, grooved end couplings shall be rigid joint for exposed service and flexible joint for buried service.
   4) Grooved end joints shall be as manufactured by one of the following:
      a) Victaulic, Style 31
      b) Or equal.
   5) For grooved-end pipe, wall thickness shall be minimum Class 53 except where the specified pressure requires heavier pipe.

e. Restrained Joints: Restrained push-on joints shall be capable of being deflected after full assembly. Joint assembly shall be in strict conformance with AWWA C600 and manufacturer's recommendations. No field cuts of restrained pipe are permitted without prior approval of the ENGINEER.

f. Restrained Joints:
   1) All pipeline valves and fittings shall have thrust blocks as shown or referenced on the drawings designed for the working pressure in addition to the restraining systems per Paragraphs:
      a). 2.1.B.3.f.2)

b) 2.1.B.3.f.3).

2) Restrained joints for mechanical joint piping shall be one of the following:
   a) Romagrip, as manufactured by Romac Industries.
   b) Megalug, Series 1100, as manufactured by EBBA Iron Sales, Inc.
   c) Stargrip, Series 3000, as manufactured by Star Pipe Products
   d) Uni-Flange Series 1400, as manufactured by Ford Meter Box.
3) Restrained joints for push-on joint piping shall be one of the following:
   a) Clow Super-lock Joint Pipe, as manufactured by Clow Cast Iron Pipe and Foundry Division of Clow Corporation.
   b) Lok-Ring Joint, or Flex-Ring Joint, as manufactured by American Cast Iron Pipe Company.
   c) TR Flex Joint, as manufactured by U.S. Pipe.
   d) Thrust-lock, as manufactured by Pacific States Pipe.
   e) Snap-Lok or Bolt-Lok, as manufactured by Griffin Pipe.
4) Split restrained joint glands for mechanical joints, or wedge action restrained joint glands for push (non-mechanical) joints, are only allowed for connection or repair to existing installed pipe. The split restrained joint or wedge glands shall be one of the following:
   a) Stargrip Series 3000S, 3100P, 3100S, as manufactured by Star Pipe Products
   b) Megalug Series 1100SD, 1100H D, as manufactured by EBAA Iron Sales, Inc.
   c) Megalug Series 1700, as manufactured by EBAA Iron Sales, Inc.
   d) Uni-Flange Series 1450, as manufactured by Ford Meter Box

4. Flanged fittings: Conform to AWWA C110 and AWWA C115. AWWA C153 compact ductile iron fittings are acceptable for use unless otherwise specified. Long-radius elbows shall be provided where specified.
   a. Minimum Pressure Rating: 250 psig unless specifically noted otherwise.
   b. Material: Ductile iron.
   c. Gaskets: As specified above for joints.
   d. Bolts and Nuts: As specified above for joints.
5. Mechanical Joint Fittings: Conform to AWWA C110. AWWA C153 compact ductile iron fittings are acceptable for use unless otherwise specified. Long-radius elbows shall be provided where specified.
   a. Minimum Pressure Rating: 250 psig unless specifically noted otherwise.
   b. Material: Ductile iron.
   c. Glands: Use ductile iron glands only. Cast iron glands are not allowed.
   d. Gaskets: As specified above for joints.
   e. Bolts and Nuts: As specified above for joints.
   f. Mechanical Joint Bolt Holes: Orient bolt holes to straddle vertical centerline.
6. Coatings and Linings:
   a. Unless otherwise specified, pipe and fittings shall be lined with epoxy lining.
   b. Where specified in Section 15050, Piping Systems, glass-lined pipe shall be provided in accordance with Section 15107, Glass Lined Ductile Iron Pipe.
   c. Buried pipe and fittings shall be coated on the outside with a bituminous coating, approximately 1-mil thick material as specified in AWWA C151. Buried flanged

joints shall be coated with a petroleum based mastic and wrapping tape system Denso Paste primer and Densyl Tape finish as manufactured by Denso, or approved equal. Exposed pipe shall be prime coated in accordance with Section 09900, Painting.

d. Polyethylene Encasement:
   1) All polyethylene film shall be manufactured in accordance with ANSI/AWWA C105/A21.5.
   2) All open cut installed buried pipe shall be provided with polyethylene encasement to prevent contact between the pipe and surrounding bedding material and backfill.
   3) Polyethylene may be supplied in tubes or in sheet material.

7. Epoxy Lining Material: Where specified in Section 15050, Piping Systems, epoxy lining shall be provided. The material shall be an amine cured novalac epoxy containing at least 20 percent by volume of ceramic quartz pigment. Epoxy lining material manufacturer shall demonstrate a successful history of lining pipe and fittings for sewer service and submit a test report verifying the following properties, and a certification of the test results.
   a. A permeability rating of 0.00 when tested according to Method A of ASTM E-96-66, Procedure A with a test duration of 30 days.
   b. The following test shall be run on coupons from factory lined ductile iron pipe:
      1) ASTM B-117 Salt Spray (scribed panel): Results to equal 0.0 undercutting after two years.
      2) ASTM G-95 Cathodic Disbondment 1.5 volts at 77°F: Results to equal no more than 0.5 mm undercutting after 30 days.
      3) Immersion Testing rated using ASTM D-714-87.
         a) 20 percent Sulfuric Acid: No effect after two years.
         b) 25 percent Sodium Hydroxide: No effect after two years.
         c) 160°F Distilled Water: No effect after two years.
         d) 120°F Tap Water (Scribed panel): 0.0 undercutting after two years with no effect.
   c. An abrasion resistance of no more than four mils loss after one million cycles - European Standard EN 598: 1994 Section 7.8 Abrasion Resistance.
   d. Interior of the pipe shall receive 40 mils dry film thickness.
   e. Applicator: The lining shall be applied by a competent firm with a successful history of applying linings to the interior of ductile iron pipe and fittings.
   f. Surface Preparation: Pipe surfaces shall be cleaned and sand blasted prior to lining application in accordance with manufacturer's recommended procedures.
   g. Inspection and Certification:
      1) All ductile iron pipe and fitting linings shall be checked for thickness using a magnetic film thickness gauge. The thickness testing shall be done using the method outlined in SSPC-PA-2 Film Thickness Rating.
      2) The interior lining of all pipe barrels and fittings shall be tested for pinholes with a non-destructive 2,500 volt test. Any defects found shall be repaired prior to shipment.
      3) The pipe or fitting manufacturer shall supply a certificate attesting to the fact that the applicator met the requirements of this specification.

h. Product and Manufacturer: Provide one of the following:
1) Protecto 401.
2) Or equal.

8. Bonded Joints:

a. All pipes 16 inches and larger shall have bonded joints.

b. Joint Bond Wires: Bond wires shall be provided across all non-conductive ductile iron pipe joints to ensure electrical continuity. Joint bonds shall be installed as shown on the drawings.
1) Joint bonds shall be made utilizing #4 AWG type HMWPE stranded conductors. Bond wires shall not exceed 18 inches in length. Connections shall be made utilizing the exothermic weld process as described below.

c. Exothermic Welds: Exothermic welds shall be provided for wire to structure connections in strict accordance with the manufacturers recommendations. Connections shall be made at locations shown on drawings. Exothermic welds shall be "Cadweld", as manufactured by Erico Products, Inc., "Thermoweld" as manufactured by Continental Industries, Inc., "Pin Brazing" by BAC, or approved equal. Duxseal packing as manufactured by Johns-Manville or approved equal shall be used where necessary to prevent leakage of molten weld metal.
1) The shape and charge of the exothermic weld shall be chosen based on the following parameters:
a) Pipe Material
b) Pipe Size
c) Wire Material
d) Number of Strands to be Welded
e) Orientation of Weld (Vertical or Horizontal)
2) Type of exothermic weld to be used shall be submitted to the Construction Manager for approval.
3) Copper sleeves specifically designed for the purpose shall be crimped on all bare wire ends of all stranded wires prior to exothermic welding to improve mechanical strength and thermal capacity.

d. Weld Caps: Welds to be buried or submerged shall be primed with an elastomer resin based primer then be covered with a 100% solids mastic filled plastic cap. Use the plastic cap on dielectric coated pipe following the manufacturer's instructions. Primer shall be Roybond Primer 747 as manufactured by Royston Laboratories, or equivalent. Weld caps shall be Royston Handy Cap, as manufactured by Royston Laboratories, Inc. Thermit Weld Cap, as manufactured by Phillips Petroleum Co. or an approved equal.

C. Couplings:
1. Refer to Section 15120, Piping Specialties and Accessories.

D. Specials:
1. Transition Pieces:
a. Furnish suitable transition pieces (adapters) for connections to existing piping.
b. Unless shown on Drawings, expose existing piping to determine material, dimensions and other data required for transition pieces.

2. Taps:
   a. Provide taps where shown on the Drawings or required for small diameter pipe connections.
   b. Provide a tapping saddle conforming to the requirements of the City of Phoenix Water Services Department. Tapping saddles shall have a maximum outlet diameter of 3".
3. Welded Outlets:
   a. Provide welded outlet fittings as shown on the Drawings.
   b. Welded-on outlets shall be limited to branch or radial outlets.
   c. Welded-on outlets may be provided as a radial (tee) outlet, or lateral outlet fabricated at a specific angle to the main line pipe, as indicated on the drawings.
   d. Outlets greater than fifty percent (50%) of the nominal diameter of the main line pipe or 12-inch, which ever is smaller, shall be an integral tee fitting.
   e. Welded outlets for ductile iron pipe are not acceptable for a tangential configuration unless shown on the plans or approved by the ENGINEER.
   f. No welding shall be permitted within 24-inches from the end of the pipe. Spacing of welded outlets shall not be closer than two times the diameter of the largest outlet.
   g. The pipe manufacturer or fabricator performing the welds shall have a minimum of 5 years experience in the fabrication and testing of outlets of similar size and configuration.
   h. The joints on welded-on branch outlets shall meet, where applicable, the requirements of ANSI/AWWA C111/A21.11 and/or ANSI/AWWA C115/A21.15.
   i. Design
      1) Weldment for welded-on outlets shall be based on the method described in Section VIII of the ASME Unfired Pressure Vessel Code. Reinforcing welds shall be placed using Ni-Rod FC 55o cored wire or Ni-Rod 55o electrodes manufactured by INCO Alloys (or an electrode with equivalent performance properties). Carbon Steel electrodes are not acceptable. 2) Parent pipe and branch outlet pipe shall be centrifugally cast ductile iron pipe designed in accordance with ANSI/AWWA C150/A21.50 and manufactured in accordance with NSI/AWWA C151/A21.51. Minimum classes shall be: for sizes 4-inch through 54-inch, Special Thickness Class 53; for sizes 60-inch through 64-inch, Pressure Class 350.
      2) Welded outlets require submittal and approval of design calculations, welding procedures, and actual structural testing results for both hydrostatic pressure as well as transverse and axial loading imposed on the outlet itself.
   j. Testing
      1) All welded-on outlets shall be rated for a working pressure of 250 psi and must have a minimum safety factor of 2.0 based on proof of design hydrostatic test results. The manufacturer shall, at the request of the owner or owner's Engineer, provide representative proof test data confirming hydrostatic test results and safety factors.
      2) Prior to the application of any coating or lining in the outlet area all weldments for branch outlets to be supplied on this project shall be subjected to an air pressure test of at least 15 psi. Air leakage is not acceptable. Any

leakage shall be detected by applying an appropriate soapy water solution to the entire exterior surface of the weldment and adjoining pipe edges or by immersing the entire area in a vessel of water and visually inspecting the weld surface for the presence of air bubbles. Any weldment that shows signs of visible leakage shall be repaired and retested in accordance with the manufacturer's written procedures.

k. Quality Assurance:
   1) The manufacturer shall have a fully documented welding quality assurance system and maintain resident quality assurance records based on ANSI/AWS D11.2, the Guide for Welding Iron Castings. The manufacturer shall maintain appropriate welding procedure specification (WPS), procedure qualification (PQR), and welder performance qualification test (WPQR) records as well as appropriate air test logs documenting air leakage tests. The manufacturer shall have ISO 9001 or 9002 registration.
   2) Prior to the start of manufacturing any proposed manufacturer not meeting ISO 9001 or 9002 registration requirements shall submit to the owner or owner's Engineer the name of an Independent Inspection Agency and the agency's qualifications. Submitted qualifications shall include but are not limited to the following:
      a) List of project references for projects of similar type and size
      b) Resumes for inspection and testing personnel
      c) Capacities for chemical and mechanical testing of material specimens
      d) Frequencies for all instrument and testing equipment certifications
   3) The independent inspection agency shall be responsible for all of the following:
      a) Verify compliance to written welding procedures specification (WPS) and procedure qualification (PQR)
      b) Verify qualification of all welders (WPQR) per ANSI/AWS D11.2 criteria
      c) Document use of Ni-Rod FC 55o cored wire or Ni-Rod 55o electrodes manufactured by INCO Alloys (or an electrode with equivalent performance properties)
      d) Witness and document all air testing of outlet welds

l. Field Welding: No field welding or field repairs shall be allowed. Should a leak be detected at a welded-on outlet after installation, the piece shall be removed and returned to the pipe manufacturer's facility, where originally produced, for repair or replacement.

2.2 MARKING FOR IDENTIFICATION

A. All pipeline materials shall be stamped, marked or identified with the following:
   1. Name or trade mark of the manufacturer.
   2. Pipe class.
   3. Size and length dimensions.
   4. Date and place of manufacture.

B. Plastic Tracer Tape: Tracer tape shall be 6-inches wide, colored the same as the background colors as specified in Section 09900, Painting, and made of inert plastic material suitable for direct burial. Tape shall be capable of stretching to twice its original length and shall be as manufactured by Allen Systems, W. H. Brady Co., Seton Name Plate Corporation, Marking Services Inc., or equal.
   1. Two messages shall be printed on the tape. The first message shall read "CAUTION CAUTION CAUTION _____ PIPE BURIED BELOW" with bold letters approximately 2-inches high. The blank shall be filled with the particular system fluid such as potable water. The second message shall read, "CALL _____" with letters approximately 3/4-inch high. The blank shall be filled in with the City telephone number. Both messages shall be printed at maximum intervals of two feet.

2.3 SURFACE PREPARATION AND SHOP PAINTING

A. Exposed pipe and fittings:
   1. Clean and prime coat ferrous metal surfaces of piping in the shop in accordance with the requirements of Section 09900, Painting.
   2. Field painting shall conform to the requirements of Section 09900, Painting.

B. Buried pipe and fittings:
   1. Refer to Paragraph 2.1.B.6.c., above

PART 3 - EXECUTION

3.1 INSTALLATION

A. For buried piping installation and testing, refer to Section 15050, Piping Systems, and Section 15051, Buried Piping Installation.

B. For exposed piping installation and testing, refer to Section 15050, Piping Systems, and Section 15052, Exposed Piping Installation.

C. Testing
   1. General:
      a. The Contractor shall test waterlines for water tightness, including all fittings and connections to the waterlines. Each pipe shall be tested for leakage and pressure in accordance with applicable provisions of AWWA standards and/or Manuals, except as modified below.
      b. The Contractor shall provide all vents, piping, plugs, bulkheads, valves, bracing, blocking, pump, including measuring device and all other equipment necessary for making the tests, except pressure gages. Contractor shall furnish all labor and material, and all water required for pressure testing and obtain all permits for test water discharge at no additional cost to the Owner. All water must be dechlorinated to negligible levels prior to discharge to any location. All test water shall be potable. No other water shall be allowed in the pipe.

c. The pipe shall be tested between the closed ends of the pipe. There shall be no testing against a valve unless otherwise approved. Pipe test section shall be limited to 2,500 linear feet, or less, unless otherwise approved in writing by the Engineer. No section of the pipeline shall be tested until all field-placed concrete or mortar has attained a strength of 3000 psi. The Contractor shall be responsible for ascertaining that all test bulkheads are suitably restrained to resist the thrust of the test pressure without damage to, or movement of, the adjacent pipe. Any unharnessed sleeve-type couplings, expansion joints, or other sliding joints shall be restrained or suitably anchored prior to the test, to avoid movement and damage to piping and equipment.

d. The test shall be made after the backfilling is completed and compacted, regardless of the compaction method.

e. All connections, blowoffs, hydrants and valves shall be tested with the main, where practical.

f. The test section shall be slowly filled with potable water and all air shall be vented from the line. The rate of filling shall be as approved by the Superintendent of Water Distribution, with at least 24-hour notice required before filling is scheduled.

g. Connections to existing pipelines or existing valves shall be made after new construction has satisfactorily passed the pressure and leakage tests and potable water piping has been flushed and disinfected in accordance with AWWA C651.

2. Pressure Test

a. Waterlines, including all fitting and connections shall be tested for water tightness by subjecting each test section to pressure test. The test pressure shall be measured at the lowest end of the test section. The test pressure shall be 188 psi unless otherwise specified. The duration of each pressure test shall be at least 2 hours. The pressure test shall begin after the pipe has been filled with water for a minimum of 48 hours to allow the concrete or mortar lining, as applicable, to absorb what water it will and to allow the escape of air from any air pockets. During this period, bulkheads, valves, and connections shall be examined for leaks. If leaks are found, corrective measures satisfactory to the Engineer shall be taken.

b. Makeup water can be added to the pipeline to maintain test pressure. The amount of make-up water does not indicate a pass or fail of the pressure test. Satisfactory test results shall be per Paragraph 3.1.C.2.c.

c. Satisfactory test results are achieved if the test pressure is maintained within 5 psi of the required test pressure for the duration of the 2-hour test.

3. Leakage Test

a. Leakage tests shall be made after pressure test has been completed and pressure test results are satisfactory.

b. The duration of each leakage test shall be at least 2 hours. Leakage test pressure shall be a minimum of 150 psi unless otherwise indicated and the test pressure shall be maintained within 5 psi of the specified leakage test pressure during the test. Water may be continually fed or added when the pressure drops 5 psi.

c. The maximum allowable leakage from the pipe line shall be determined by the applicable formula:

$$L = \frac{ND\sqrt{P}}{7400}$$

in which:

L = allowable leakage in gallons per hour

N = number of joints in the main run pipe being tested, with no allowance for joints at branches, blowoff, fittings, and similar appurtenances. "N" is calculated using the standard length of pipe installed divided into the length being tested.

D = nominal inside diameter of pipe in inches.

P = average test pressure, in psi gage, as measured at the lowest point in the test section.

d. Should the test on any section of the pipeline show leakage greater than specified above, the Contractor shall locate and correct until the leakage is within the specified allowance for a 2-hour duration. All repairs and retests shall be at the Contractor's expense.

e. Leakage is defined as the quantity of make-up water necessary for the test section to maintain the specified leakage test pressure after the pipeline has been filled with water and all air expelled.

4. Cleaning and Flushing: Cleaning and flushing shall be per Section 15050-3.6.

D. Polyethylene Encasement:
1. Encase all ductile iron pipe with polyethylene in accordance with ANSI/AWWA C105/A21.5.
2. Repair any rips, punctures or other damage to the tube with the adhesive tape or pieces of tube material secured with tape.

3.2 PIPING IDENTIFICATION

A. Pipe Coding: After application of the specified coating and insulation systems, exposed piping, interior and exterior, and piping in ceiling spaces, pipe trenches, pipe chases and valve boxes shall be identified with painted bonding and lettering as specified in Paragraph 2.2, above. Legend markers and directional arrows shall be located at each side of walls, floors and ceilings, at one side of each piece of equipment, at piping intersections, and at approximately 25-foot centers.

B. Plastic Tracer Tape: A single line of tape as specified in Paragraph 2.2.B., above, shall be provided 2.5 feet above the centerline of buried ferrous pipe. For pipelines buried eight feet or greater below finished grade, provide a second line of tape 12-inches below finished

grade, above and parallel to each buried pipe. Tape shall be spread flat with message side up before backfilling.

3.3 BONDED JOINTS

A. Description: Upon completion of installation of all components as shown on the drawings and in accordance with these specifications, testing shall be performed to demonstrate that the installation has been completed and is in working order in conformance with the drawings and specifications. In no case shall the testing be less than those tests outlined herein unless requested in writing by the Contractor and approved by the Construction Manager. The testing described herein shall be in addition to and not a substitution for any required testing of individual items at the manufacturers' plant. The Contractor shall provide testing of the system. The test data shall be submitted to the Construction Manager for acceptance to demonstrate that the system is in proper working order. The cost of the testing shall be borne by the Contractor, including any additional expenses which result from retesting due to equipment or installation which is not in conformance with these specifications and drawings.

B. Joint Bond Wires: Joint bond wires shall be installed as shown on the drawings. Make connections by the exothermic weld process per 3.3.C. After installation, all joint bonds shall be tested for effectiveness. The testing shall be performed prior to backfill of the pipe and shall be verified upon completion of backfilling operations. Prior to backfilling, current shall be circulated through the pipe and the measured resistance shall be compared to the theoretical resistance of the pipe and bond wires. The resistance measured shall not exceed 120 percent of the theoretical resistance. Once backfilling operations have been completed, the testing shall be repeated to ensure continued effective continuity. All data shall be tabulated and submitted upon completion of testing and prior to final acceptance of the contract.

C. Exothermic Welds: Exothermic weld connections shall be installed in the manner and at the locations shown on the plans. Coating materials shall be removed from the surface over an area of sufficient size to make the connection. The steel surface shall be cleaned to shiny metal by grinding or filing prior to welding the conductor. The use of resin impregnated grinding wheels will not be allowed. The conductor shall be welded to the pipe by the exothermic welding process with a copper sleeve fitted over the conductor. Only enough insulation shall be removed such that the copper conductor can be placed in the welding mold. After the weld has cooled, all slag shall be removed and the metallurgical bond shall be tested for adherence to the pipe or casing. All defective welds shall be removed and replaced. All exposed surfaces of the copper and steel shall be covered with insulating materials as shown in the detail drawings. No connections to the piping shall be buried prior to inspection and approval of the Engineer. Connections made in violation of this requirement shall be rejected.

D. Welds shall be primed with an elastomer resin based primer, covered with a weld cap, and then over-coated with bitumastic.

E. Exothermic welds shall be tested by the Contractor for adherence to the pipe or casing and for electrical continuity between the pipe or casing and wires. Test completed weld by striking weld with a hammer and pulling on wire. A 22-ounce hammer shall be used for adherence testing by striking a blow to the weld. Care shall be taken to avoid hitting the wires.

3.4 INSPECTION

A. Inspect all piping to assure that piping is free from defects in material and workmanship. The compatibility of all pipe, fittings, gaskets and coatings shall be verified.

+ + END OF SECTION + +

SECTION 15102

STEEL PIPE, FITTINGS, AND SPECIALS

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Provide all labor, materials, equipment, tools, services, testing, and incidentals to install complete all steel water pipe, fittings, and specials.

B. This section describes materials and fabrication of lined and coated welded steel pipe with fittings and pipe specials in accordance with AWWA C200 as modified herein.

C. The extent of steel pipe to be provided is shown on the Drawings.

1.2 DEFINITIONS

A. A special is defined as any piece of pipe other than a normal full length of straight pipe. Fittings and specials include, but are not limited to, short pieces, manhole sections, closure pieces, bends, elbows, reducers, tees, wyes, bifurcations, crosses, outlets, manifolds, nozzles, wall sleeves, bulkheads, vent pipes, and other piping and appurtenances fabricated from steel plate, sheet, or coils as required to complete the Work. Specials shall also include piping above ground or inside structures.

B. Acronyms:
   1. CJP: Complete Joint Penetration
   2. CWI: Certified Welding Inspector.
   3. MPS: Main pipe supplier.
   4. MT: Magnetic Particle Testing.
   5. NDE: Nondestructive Examination.
   6. NDT: Nondestructive Testing.
   7. PQR: Procedure Qualification Record.
   8. PT: Liquid Penetrant Testing.
   9. RT: Radiographic Testing.
   10. UT: Ultrasonic Testing.
   11. VT: Visual Testing.
   12. WQR: Welder/Welding Operator Performance Qualification.
   13. WPS: Welding Procedure Specification

1.3 REFERENCES

A. General:
   1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to

other standards, those documents are included as references under this section as if referenced directly. In the event of a conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of construction. If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued.
3. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

B. American National Standards Institute (ANSI):
   1. B16.1, Cast Iron Pipe Flanges and Flanged Fitting, Class 25, 125, 250, and 800
   2. B16.3, Malleable Iron Threaded Fittings, Class 150 and 300.
   3. B16.5, Steel Pipe Flanges, Flanged Valves, and Fittings
   4. B16.9, Factory-Made Wrought Steel Buttwelding Fittings.
   5. B16.11, Forged Steel Fittings, Socket-Welding and Threaded.
   6. B36.10, Welded and Seamless Wrought Steel Pipe.

C. American Petroleum Institute (API):
   1. Std. 1104, Welding of Pipelines and Related Facilities

D. American Society of Mechanical Engineers (ASME):
   1. BPVC SEC V, Nondestructive Examination.
   2. BPVC SEC VIII, Div. 1, Rules for Construction of Pressure Vessels.
   3. BPVC SEC IX, Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators.
   4. B1.20.1, Pipe Threads, General Purpose (inch)

E. American Society for Nondestructive Testing Inc. (ASNT):
   1. SNT-TC-1A, Personnel Qualification and Certification in Non-Destructive Testing.

F. American Water Works Association (AWWA):
   1. C200, Steel Water Pipe – 6 inch (150 mm) and Larger.
   2. C205, Cement-Mortar Protective Lining and Coating for Steel Water Pipe - 4 in. (100 mm) and Larger – Shop Applied.
   3. C206, Field Welding of Steel Water Pipe.
   4. C207, Steel Pipe Flanges for Waterworks Service – Sizes 4-Inch Through 144-Inch.
   5. C208, Dimensions for Fabricated Steel Water Pipe Fittings.
   6. C209, Cold-Applied Tape Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines.
   7. C210, Liquid-Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines.

8. C213, Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines.
9. C214, Tape Coating Systems for the Exterior of Steel Water Pipelines.
10. C216, Heat-Shrinkable Cross-Linked Polyolefin Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines.
11. C218, Coating the Exterior of Aboveground Steel Water Pipelines and Fittings.
12. C219, Bolted, Sleeve-Type Couplings for Plain-End Pipe.
13. C221, Fabricated Steel Mechanical Slip-Type Expansion Joints.
14. C222, Polyurethane Coatings for the Interior and Exterior of Steel Water Pipe and Fittings.
15. C602, Cement-Mortar Lining of Water Pipelines in Place – 4 in. (100 mm) and Larger.
16. C604, Installation of Steel Water Pipe-4 In. (100mm) and Larger.
17. M11 (Manual), Steel Water Pipe - A Guide for Design and Installation.

G. American Welding Society (AWS):
1. A2.4, Standard Symbols for Welding, Brazing, and Nondestructive Examination.
2. A3.0, Standard Welding Terms and Definitions.
3. B2.1, Standard for Welding Procedure and Welding Qualifications.
4. D1.1, Structural Welding Code – Steel.
5. QC 1, Standard for AWS Certification of Welding Inspectors.

H. ASTM, International (ASTM):
1. A20, Standard Specification for General Requirements for Steel Plates for Pressure Vessels.
2. A36, Specification for Carbon Structural Steel.
3. A47, Ferritic Malleable Iron Castings.
4. A53/A53M, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
5. A105, Forgings, Carbon Steel for Piping Components.
6. A106, Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service.
7. A134, Standard Specification for Pipe, Steel, Electric-Fusion (Arc)-Welded (Sizes NPS 16 and over).
8. A135, Standard Specification for Electric-Resistance-Welded Steel Pipe.
9. A139, Standard Specification for Electric-Fusion (Arc)-Welded Steel Pipe (NPS 4 and over).
10. A193, Specification for Alloy-Steel and Stainless Steel Bolting Materials for High Temperature Service.
11. A197, Cupola Malleable Iron.
12. A234/A234M, Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.
13. A283, Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates.
14. A307, Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
15. A325, Specification for High-Strength Bolts for Structural Steel Joints

16. A370, Standard Test Methods and Definitions for Mechanical Testing of Steel Products.
17. A435/A435M, Standard Specification for Straight-Beam Ultrasonic Examination of Steel Plates.
18. A516/A516M, Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service.
19. A536, Ductile Iron Castings.
20. A572/A572M, Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel.
21. A635, Standard Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Carbon, Hot-Rolled.
22. A673, Standard Specification for Sampling Procedure for Impact Testing of Structural Steel.
23. A770/A770M, Standard Specification for Through-Thickness Tension Testing of Steel Plates for Special Applications.
24. A1008/A1008M, Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable
25. A1011/A1011M, Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability.
26. A1018/A1018M, Standard Specification for Steel, Sheet and Strip, Heavy Thickness Coils, Hot Rolled, Carbon, Commercial, Drawing, Structural, High-Strength Low-Alloy, and High-Strength Low-Alloy with Improved Formability.
27. C150, Specification for Portland Cement
28. D297, Standard Test Methods for Rubber Products – Chemical Analysis.
29. D395, Standard Test Methods for Rubber Property – Compression Set.
30. D412, Standard Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers – Tension.
31. D573, Standard Test Method for Rubber-Deterioration in an Air Oven.
32. D2240, Standard Test Method for Rubber Property – Durometer Hardness.
33. D4541, Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers.
34. D4894, Specification for PTFE Granular Molding and Ram Extrusion Materials.
35. D4895, Specification for PTFE Resins Produced from Dispersion.
36. E165, Methods for Liquid Penetrant Inspection
37. E329, Standard Specification for Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction.
38. E340, Standard Test Method of Macroetching Metals and Alloys.
39. E1255, Standard Practice for Radioscopy.
40. F1545, Specification for Plastic-Lined Ferrous Metal Pipe, Fittings and Flanges.

I. International Institute of Welding (IIW).

J. International Organization for Standardization (ISO).

K. NSF International (NSF):
   1. 60, Drinking Water Treatment Chemicals - Health Effects.
   2. 61, Drinking Water System Components - Health Effects.

L. Steel Pipe Fabricators Association (SFPA).

M. Steel Structures Painting Council (now Society for Protective Coatings):
   1. SP-10, Near-White Blast Cleaning.

N. Maricopa Association of Governments (MAG), Uniform Standard Specifications and Details for Public Works Construction.

O. City of Phoenix Supplement to Maricopa Association of Governments Uniform Standard Specifications.

1.4 QUALITY ASSURANCE

A. Pipe, Fittings, and Specials Manufacturer Qualifications:
   1. Manufacturer shall have a minimum of five years experience in the fabrication and production of lined and coated steel pipe, fittings, and specials of similar diameters, lengths, and wall thickness required for the Work. Provide references of satisfactory service in at least five installations.
   2. Steel pipe, fittings, specials, coating, and linings shall be the product of or applied by one manufacturer.
   3. Steel Pipe Fabricators Association (SPFA), Lloyd's Registry Certification, or ISO 9000 Certification.
   4. Demonstrate current production capability for volume of work required for this project.
   5. Experience shall include successful fabrication to AWWA C200 standards of at least 1,000 lineal feet of 4-inch diameter or larger within past 5-year period.
   6. Experience shall include successful fabrication to AWWA C200 and AWWA C208 standards of at least 1,000 lineal feet of 4-inch diameter or larger within past 5-year period.
   7. Experience shall include successful fabrication of at least 20 crotch plate fittings or specials within past 5-year period.
   8. Experience shall be applicable to fabrication plant facilities and personnel not company or corporation that currently owns fabrication facility or employs personnel.

B. Shop and Field Welders and Welding Operator Qualifications:
   1. Shop and Field Welders qualified in accordance with ASME BPVC SEC IX or AWS D1.1 by an in-house or independent local approved testing agency. If in-house testing is utilized, it shall be certified by an independent testing agency not more than 2 years prior to commencing work on the pipeline.
   2. Conduct field welder qualification testing. Submit copies of all test data and certifications.

C. Welding Requirements:
   1. Pre-qualified welding procedures per AWS D1.1 or ASME.
   2. Welding procedures required for, but not necessarily limited to, longitudinal and girth or spiral welds for pipe cylinders, reinforcing plates and ring flange welds, and plates for lug connections.
   3. Welding Procedure Specification (WPS):
      a. Qualified by testing in accordance with ASME BPVC SEC IX for shop welds and AWS D1.1 for field welds.
      b. PQRs conducted on unlisted base metal (most coil products are unlisted base metals) to be production welded as required in the referenced welding code and traceable to heat lots.
      c. Written WPS required for shop and field welds.
      d. Qualify PQRs for notch tough welding with consideration for thickness of steel, test temperature, and Charpy V-notch CVN values. Refer to AWS D1.1, Annex III Requirements for CVN Testing, Option A (three specimens). Using this test procedure select test temperature and minimum average energy level for Charpy Testing, the welding position as it may relate to heat input on the heat affected zone (HAZ) test results, and the orientation of the test plates as these relate to the longitudinal or transverse properties of the HAZ. See Part 2, Products, Article Pipe Barrel for Charpy V-notch acceptance criteria.

D. Inspection:
   1. All pipe is subject to inspection at the place of manufacture in accordance with the provisions of AWWA C200, C205, C206, C207, C208, C209, C210, C214, and C222 respectively, as supplemented by the requirements herein.
   2. Certified Welding Inspector (CWI)
      a. Certified in accordance with AWS QC 1 with knowledge of appropriate welding code for the Work.
      b. At least 2 years of professional experience related to welding inspection similar to the Work, provided that all CWI's with less than 5 years' experience are under the supervision of a CWI with 5 or more years experience.
      c. For shop welding, manufacturer shall provide a full-time CWI to perform required inspection duties per AWWA C200 and the following:
         1) Verify conformance to use of specified materials and their proper storage
         2) Monitor conformance to approved WPS.
         3) Monitor conformance to approved NDT procedure specifications.
         4) Monitor conformance of WQR.
         5) Provide 100 percent visual inspection before, during, and after shop welding.
         6) Supervise NDT personnel and evaluate test results.
         7) Maintain records and prepare report confirming results of inspection and testing.
      c. Provide CWI for field welding. The CONTRACTOR will provide an independent CWI for other NDT of field welding.
   3. Inspection of Coating and Lining Application: In accordance with the applicable pipeline coating and lining system specification.

E. Testing:
   1. Except as modified herein, all materials tested in accordance with the requirements of AWWA C200, C205, C207, C208, C209, C210, C214, and C222 as applicable.
   2. Prior to lining, shop-test and certify each length of pipe of each diameter and pressure class to a pressure of at least 75 percent of the yield strength of the pipe steel. Minimum duration of test shall be 30 seconds.
   3. In addition to the tests required in AWWA C200, conduct weld tests on each 3,000 feet of production welds and at any other times there is a change in the grade of steel, welding procedure, or welding equipment.
   4. The Engineer shall have the right to witness all testing.
   5. Manufacturer to test coating and lining system in shop and prepare letter confirming that materials applied conform to these Specifications. Tests include holiday detection, adhesion testing, and film thickness measurement.
   6. In addition to those tests specifically required, the Engineer may request additional samples of any material including lining and coating samples for testing by the Owner.

F. Prefabrication Meeting: Hold prefabrication meeting not less than 14 calendar days prior to the start of fabrication of pipe, fittings, or specials between representatives of Owner, Contractor, Engineer, and pipe manufacturer to review the following:
   1. Project scope.
   2. Submittal requirements.
   3. Testing.
   4. Inspection responsibilities.
   5. Shop welding requirements.
   6. Field welding requirements.
   7. Shop and field coating and lining requirements.
   8. Production and delivery schedule.
   9. Other issues pertinent to the Work.

G. Manufacturer's Field Service Representative:
   1. Provide manufacturer experienced staff member to be onsite while the pipe and fittings are being installed. The staff member shall be onsite for the first week of the pipe installation and a minimum of 4 hours per week for 2 weeks thereafter.
   2. Manufacturer Field Service Representative's duties include, but not be limited to the following:
      a. Inspect pipe upon delivery to site.
      b. Observe pipe handling, moving, storage, hoisting and installation operations.
      c. Report any concerns to the Contractor and/or Engineer's onsite observer.
      d. Answer questions and provide assistance to the Engineer and the Contractor.
      e. Instruct installer in proper field mortar lining repair and dielectric coating repair of pipe, fittings, or specials.

1.5 SUBMITTALS

A. Prepare submittals for steel pipe and steel pipe fittings and specials by a single pipe manufacturer only.

B. Shop Drawings: Submit Shop Drawings in accordance with the requirements of ANSI/AWWA C200, C205, C207, C209, C210, C214 and C222 and the following supplemental requirements as applicable:

1. Design calculations for all pipe, fittings, and specials, including determination of wall thickness satisfactory for external loading, special loading, internal pressure and details of opening reinforcement (collars, wrappers, or crotch plates).
2. Material lists and steel reinforcement schedules that include and describe all materials to be used.
3. Line layout and marking diagrams in accordance with AWWA M11. Indicate the specific number of each pipe and fitting and the location of each pipe and the direction of each fitting in the completed line. Line layouts drawings and diagrams criteria:
    a. Based on the stationing and elevation convention as shown on Drawings.
    b. Select individual pipe segment lengths to accommodate the installation operation. Maximum pipe segment length shall be 25 feet.
    c. Number each pipe segment in installation sequence.
    d. Include the pipe station and elevation at all changes in grade or horizontal alignment.
    e. Include the station and elevation to which the bell end of each pipe will be laid.
    f. Include all elements of curves and bends, both in horizontal and vertical alignment.
    g. Include the location of mitered pipe sections, beveled ends and/or pulled joints for alignment conformance, butt straps, and deep bell lap joints for temperature stress control.
    h. Include the limits of each reach of restrained and/or welded joints, concrete encasement, or casing.
    i. Include the location of closures, cut-to-fit for length adjustment, temporary access manways, vents, and weld lead outlets for construction convenience.
    j. Provide for adjustment in pipe laying headings and conform to stationing. Changes in location or number require Engineer approval.
    k. Include the location of bulkheads, both those shown and as required, for hydrostatic testing of pipeline.
4. Fabrication Information:
    a. Joint and pipe/fitting wall construction details which indicate the type and thickness of cylinder; manufacturing tolerances, and all other pertinent information required for the manufacture of the product. Submit joint details where deep bell or butt strap joints are required for control of temperature stresses.
    b. Pipe and fitting details for temporary and permanent facilities indicating:
        1) Cylinder thickness.
        2) Manufacturing tolerances.
        3) Maximum angular deflection limitations of field joints.
        4) Closure sections and cutoffs for field length adjustment.

5) Bulkheads, including details for removal of test bulkheads and repair of lining.
6) Weld lead outlets and plugs.
7) Stulling size, spacing, and layout.

c. Rubber-gasketed bell and spigot joint details including:
1) Depth of bell
2) Length of flat bell
3) Minimum/maximum engagement
4) Holdbacks for coating/lining
5) Weld-bead grindbacks
6) Tolerances

d. Welded joint details including:
1) Butt joints.
2) Miter-cut ends for alignment conformance.
3) Lap joints.
4) Deep bell lap joints required for control of temperature stresses.
5) Butt strap joints.

5. Welding Data (Shop and Field Welding):
a. Full and complete information regarding location, type, size, and extent of all welds shall be shown on the Shop Drawings.
b. Distinguish between shop and field welds.
c. Indicate by welding symbols or sketches the details of the welded joints and the preparation of parent metal required to make them.
d. Joints or groups of joints in which welding sequence or technique are especially important shall be carefully controlled to minimize shrinkage stresses and distortion.
e. Welding and NDE symbols in accordance with AWS A2.4.
f. Welding terms and definitions in accordance with AWS A3.0.

6. Details and dimensional drawings of all valves, meters, pumps, and other equipment or appurtenances determining pipe dimensions.

7. A statement from the pipe manufacturer certifying that all pipes will be fabricated, coated, and lined subject to a recognized Quality Assurance/Quality Control Program. Submit an outline of the program for review prior to pipe fabrication.

C. Product Data:
1. Pipe, Fittings, and Specials:
a. Material data.
1) Mill test reports, within one week of receiving coil
2) Coil plant chemical and physical test reports showing data consistent with specified requirements for each heat of steel proposed for use, within four (4) weeks of conducting tests.
3) Mill test reports for flanges including details of stress relief used.
b. Pipe handling equipment and methods for loading and unloading pipe.

2. Coatings and Linings:
a. Technical data sheets itemizing chemical composition, technical, and performance information that indicates compliance with this Specification.

b. Color chart, if applicable.
c. Manufacturer's name, product number or name, and thickness.

3. Mill certificates for cement used in fabrication of piping.
4. Test reports on physical properties of rubber gaskets for the characteristics specified hereinafter.

D. Certificates:
1. Furnish a certified affidavit of compliance for all pipe and other products or materials furnished under this Section of the Specifications, as specified in ANSI/AWWA C200, C205, C209, C210, C214, and C222 respectively, and the following supplemental requirements:
   a. Physical and chemical properties of all steel including mill certification for each heat from which steel is rolled.
   b. Hydrostatic test reports.
   c. Results of production weld tests.
   d. Certifications for all welders.
2. Furnish certificates for welding rods used for shop and field wielding.
3. Lining Materials: Certificate that lining system is currently approved for potable water contact in accordance with NSF 61 and satisfies current applicable governmental health and safety requirements for use in potable water.

E. Statements of Qualification:
1. Pipe, Fittings, and Specials manufacturer.
2. Welders or Welding Operators:
   a. Name of welder.
   b. Welding procedures/positions for which welder is qualified to weld.
   c. Assigned certification stamp number.
   d. Certification date.
   e. Current certification status.
3. Certified Welding Inspector for shop welding.
4. NDT Quality Control Personnel.

F. Procedures:
1. Shop and field welding information: Include welding code documentation including:
   a. Written WPS and PQR.
      1) Provide complete joint dimensions and details showing bevels, groove angles, root face, and root openings for all welds.
      2) When notch-tough welding is required:
         a) For shop welding: address supplementary essential variables in addition to essential variables as indicated in ASME Section IX, QW-251.2.
         b) For field welding: heat-input control PQR essential variables as indicated in AWS D1.1 shall be included.
         c) For shop and field welding: provide heat-input table on WPS's for welder guidance.

3) PQRs for notch-tough welding shall document heat-input control by monitoring volts, amps, and travel speed or time-rate of change of weld metal volume as calculated by measuring change in electrode length over a period of time. Charpy V-notch tests shall be conducted on weld metal and heat affected zone. Test coupons shall be oriented transverse to final direction of rolling. Full size Charpy specimen test acceptance shall be same as base metal specified herein.

b. Written NDT procedures.
c. Current WQR.

2. Contractor's written description of proposed sequencing of events or special techniques including:
   a. Temperature stress control for pipe wall during installation.
   b. Minimizing distortion of steel.
   c. Monitoring pipeline temperatures during installation.
3. Written weld repair procedures for the Work.
4. Field coating application and repair.
5. Field lining application, repair, and moisture control in accordance with AWWA C602, C210, or AWWA C222.

G. Shop-Applied Cement-Mortar Lining: Include description of machine to be used and list of similar projects where machine was used. Identify pipe size and total footage.

H. Reports:
1. Source Quality Control Test Reports:
   a. Hydrostatic testing.
   b. Destructive weld testing.
   c. Nondestructive weld testing.
   d. Steel impact testing using Charpy V-notch method.
   e. Test reports on physical properties of rubber used in the gaskets.
2. Field Quality Control Test Reports:
   a. Weld tests on each weld joint for Leak Testing (LT).
   b. Applicator's quality control records, including environmental conditions, dry film thickness, and adhesion tests, when requested by Engineer.
3. Cement-mortar lining compressive strength tests in accordance with AWWA C205.
4. Cement-mortar coating absorption tests in accordance with AWWA C205.
5. Field-applied cement mortar lining moisture control in accordance with AWWA C602.

I. Field Testing Plan: Submit at least 15 days prior to testing and include at least the following information:
1. Testing dates.
2. Piping system and sections to be tested.
3. Method of isolation.
4. Method of conveying water from source to system being tested.
5. Calculation of maximum allowable leakage for piping sections to be tested.

1.6 PRODUCT HANDLING, DELIVERY, AND STORAGE

A. Pipe Marking:
   1. Legibly mark installation sequence number on pipe, fittings, and specials in accordance with piping layout.
   2. Number each pipe in sequence and said number shall appear on the laying schedule and marking diagram in its proper location for installation.
   3. Mark special pipe sections and fittings at each end with notation "TOP FIELD CENTERLINE".
   3. Paint or mark the word "TOP" on outside top spigot of each pipe section. Straight pipe sections that are single lap-welded or o-ring gasket will not require marking of field top.
   4. Mark "TOP MATCH POINT" for compound bends per AWWA C208 so end rotations can be easily oriented in field.

B. Handling:
   1. Handle the pipe using wide slings, padded cradles, or other devices designed and constructed to prevent damage to the pipe coating/exterior.
   2. Do not use chains, hooks, or other equipment that might injure the pipe coating/exterior.
   3. Use pipe handling equipment and methods acceptable to the Engineer.
   4. Lift straight sections of pipe with two straps placed at approximate third points.
   5. Prevent damage of the coating caused by handling and/or storage of the completed pipe at low temperature.
   6. When being shipped and stock-piled at the factory, support each pipe such that damage to pipe, lining, and coating is prevented. Pipe that is not stacked may be shipped and supported with dunnage and blocking.
   7. Do not roll the pipe and secure to prevent accidental rolling.
   8. Pad tie down devices in contact with the pipe.

C. Delivery:
   1. Securely bulkhead or otherwise seal ends of pipe, specials, and fittings prior to loading at manufacturing site.
   2. Pipe ends shall remain sealed until installation.
   3. Unload pipe using equipment and methods as approved by MPS and in accordance with MPS pipe handling submittal.
   4. Damage to pipe, fittings, or specials, including linings and coatings, found upon delivery to jobsite shall be repaired or removed from site and replaced.

D. Storage:
   1. Support pipe securely to prevent accidental rolling.
   2. Support on sand or earth berms free of rock exceeding 1.5-inches in diameter.

1.7 SEQUENCING AND SCHEDULING

A. Notify Engineer in writing of the following pipe manufacturing events:
   1. Pipe Manufacturing: Not less than 14 days prior to starting.

2. Not less than 5 days prior to start of each of the following:
   a. Coating application.
   b. Lining application
   c. Shop hydrostatic testing.

1.8 CLEANUP

A. After completion of the Work, remove all remaining pipe cuttings, joining and wrapping materials, and other scattered debris from the site. Hand-over the entire piping system in a clean and functional condition.

PART 2 - PRODUCTS

2.01 GENERAL

A. Manufacture of steel pipe and steel pipe fabricated specials shall be under the direction and management of one steel pipe supplier only. The responsibility of the manufacturer shall include, at a minimum:
   1. Ensure pipe, fittings, and specials are being manufactured in full accordance with the Drawings and Specifications.
   2. Manage the design and fabrication of the pipe and specials.
   3. Prepare and submit submittal information and shop drawings.
   4. Make any corrections that may be required to the submittal information and shop drawings.
   5. Certify that the pipe and specials have been manufactured in accordance with the Specifications and Drawings.

B. Lined and coated steel pipe, fittings, and specials shall conform to AWWA C200, C205, C208, C209, C210, C214, C216, C222, and additional requirements of these Contract Documents. The pipe shall be of the nominal diameter indicated with minimum wall thickness of 0.25-inches unless indicated otherwise, shall be furnished complete, as indicated in the Contract Documents, and all specials and bends shall be provided as required under the Contract Documents.

C. For pipe 18 inches in diameter and larger, the inside diameter after lining shall not be less than the nominal diameter specified or shown. Pipe smaller than 18 inches in diameter may be furnished in standard outside diameters according to AWWA (ANSI B36.10).

D. Furnish NSF 61 materials approved for use with potable water.

E. Stulling (Strutting): Provide adequate stulling for all specials, fittings, and straight pipe so as to avoid damage to the pipe and fittings during handling, storage, hauling, and installation.
   1. Materials:
      a. For shop-lined pipe: Wood stulls and wedges.
      b. For unlined pipe: Wood or steel.

2. Submit the details of the stulling assembly for review by the Engineer prior to the start of pipe manufacture.
3. Place stulling as soon as practicable after the lining has been applied and remain in place while the pipe is loaded, transported, unloaded, installed, and backfilled at the jobsite.
4. At a minimum, place one set of stulls 2 feet from each end of pipe section and at maximum interval of 15 feet.
5. Repair or replace any pipe or pipe-lining damaged during handling, hauling, storage, or installation due to improper stulling.

F. Maximum Laying Lengths: 20 feet with shorter lengths provided as required.

G. Offset Tolerances: AWWA C200.

H. Roundness Tolerances: AWWA C200.

I. Lining: Smooth dense interior surfaces and free from significant fractures, excessive interior surface crazing and roughness.

J. Closures and Correction Pieces: Provided as required so that closures may be made due to different headings in the pipe laying operation and so that correction may be made to adjust the pipe laying to conform to pipe stationing shown. Coordinate the locations of correction pieces and closure assemblies with the manufacturer. When field closures and field adjustments are required, cut and bevel pipe using automated machines assuring good workmanship.

2.02 STEEL PIPE, FITTINGS, AND SPECIALS DESIGN CRITERIA

A. Design in accordance with the recommended procedures in AWWA Manual M11, as complemented and modified herein. Manufacture shall design pipe and fittings.

B. Pipe Design Criteria:
1. Determine minimum pipe wall thicknesses based upon the following criteria. Working internal pressure shall be 150 psi. Test internal pressure shall be 188 psi. Minimum pipe wall thickness is the minimum thickness allowed, with zero (0) inches minimum tolerance.
2. Cylinder Thickness for Internal Pressure: For resistance to internal pressure, the thickness of the steel cylinder shall be the greater of that determined by the following 2 formulas:

$$(1)\quad T=\frac{P_w D/2}{Y/S_w} \qquad (2)\quad T=\frac{P_t D/2}{Y/S_t}$$

Where:

T = Steel cylinder thickness in inches

D = Outside diameter of steel cylinder in inches

P_w = Design static or working pressure, in psi

P_t = Design test/transient/pump shut-off pressure, in psi

Y = Specified minimum yield point of steel in psi

S_w = Safety factor of 2.0 at working pressure

S_t = Safety factor of 1.5 at test/transient pressure

3. In no case shall the design stress (Y/S_w) exceed 21,000 psi at design working pressure, P_w, nor shall the design stress (Y/S_t) exceed 28,000 psi at design test/transient pressure, P_t, nor shall the steel shell thickness be less than shown on the Drawings or as presented in the following table:

Nominal Pipe Diameter (in)	Minimum Cylinder Thickness (in)
24 and less	0.135
25-30	0.150
31-36	0.180
37-42	0.200
43-48	0.225
49-54	0.250
55-60	0.265
61 and above	D/t<230

4. Cylinder Thickness for External Load:
   a. Upon determination of cylinder thickness, deflection of the pipe shall be checked by the following formula:

$$Defl_x = \frac{DKWr^3}{EI + 0.061\ E'r^3}$$

Where:

$Defl_x$ = Vertical deflection of pipe in inches, not to exceed: 0.030 times the nominal diameter for flexible coating

D=Deflection lag factor, 1.25

K=Bedding constant, 0.1

W_c=Vertical load on pipe, lb/in (see note 1)

r=Mean radius of pipe cylinder, inches

EI=Pipe wall stiffness, lb-in (see note 2)

E'=Modulus of soil reaction, lb/in^2 (see note 3)

Note (1): For depths of cover up to and including 15 feet, the earth load shall be computed assuming the prism loading condition as applicable. For depths of cover greater than 15 feet, the earth load may be computed using the prism load or trench condition equation, (AWWA M11, Equation 6-1), based upon the anticipated construction methods. For depths of cover less than 9 feet, HS-20 live load shall be included. For depths of cover of 3 feet or less, HS-20 live load plus impact shall be included. The determination of live load and impact factors shall be as recommended by AWWA, Manual M11.

Prism Loading Condition:

$W_c = wH_cB_c$

Where:

W_c = Earth Load in pounds per linear foot

H_c = Height of fill above top of pipe, feet

w = 120 lb/ft^3

B_c = Outside diameter of pipe, feet

Note (2): Based on the sum of the pipe wall stiffnesses, EI, mortar lining, and steel cylinder assuming that it acts as a two-part laminar ring which considers no bond between the steel cylinder and the applied lining. The term "pipe wall stiffness" as used herein is defined as EI, where "E" is the modulus of elasticity (E=29,000,000 psi for steel and E=4,000,000 psi for mortar) and "I" is the transverse moment of inertia per unit length of pipe wall, the factors in the foregoing expression to be dimensionally compatible.

Note (3): E' = 1,500 psi for pipe bedding material based on 90 percent Standard Proctor or 70 percent relative density for pipe cover depths between 5 feet and 15 feet. For pipe burial depths less than 5 feet or greater than 15 feet or alternative pipe bedding materials, designer may use alternate E' values provided that the rationale for developing the alternate E' value is acceptable to the Owner. E' = 2,500 psi for controlled low-strength material (CLSM).

b. If the calculated deflection, $Defl_x$, exceeds the allowable, improve the quality of pipe zone backfill to achieve a higher E' value (e.g. higher compaction, controlled-low strength material, lean concrete, etc.). Alternatively, thicken the composite pipe section.

5. Cylinder Thickness for Confined Buckling: Pipe embedded in soil (i.e., confined) may collapse or buckle from elastic instability resulting from external loads and

deformations. Check the cylinder thickness per AWWA M-11 for the project specific design conditions.

6. Cylinder Thickness for Unconfined Buckling in cased crossing.
7. Cylinder Thickness for Stresses in pipe associated with Poisson's effect, thrust, temperature, and bending.
8. Design steel pipe and welds between pipe segments for the axial thrust exerted by full static, working or test/transient/pump shut-off pressure, whichever is greater. Base calculations of thrust on a friction factor between pipe and soil of 0.3.
9. Minimum Cylinder Thickness for Handling: D/t = 230, where D = Nominal Diameter and t = wall thickness.

C. Fittings and Specials Design Criteria:

1. Except as otherwise provided herein, materials, fabrication and shop testing of fabricated specials shall conform to the requirements of ANSI/AWWA C200, and shall conform to the dimensions of ANSI/AWWA C208. The minimum thickness of steel for pipe from which specials are to be fabricated shall be the greater of that determined by the following 2 formulas:

$$(1)\quad T = \frac{P_w D/2}{Y/S_w} \qquad (2)\quad T = \frac{P_t D/2}{Y/S_t}$$

Where:

T = Steel cylinder thickness in inches

D = Outside diameter of steel cylinder in inches

Pw = Design working pressure, in psi

Pt = Design test pressure, in psi

Y = Specified minimum yield point of steel (psi)

Sw = Safety factor of 2.0 at working pressure

St = Safety factor of 1.5 at test pressure

2. In no case shall the design stress at design working pressure (Y/Sw) for steel pipe specials exceed 21,000 psi or 28,000 psi at design transient pressure (Y/St). Wall thickness for elbows shall recognize the stress intensification, inherent in the elbow geometry in accordance with AWWA Manual M-11, Equation 9-3. Wall thickness shall not be less than the thickness of adjacent mainline pipe.
3. Design pipe installed on saddle supports based on limiting the longitudinal bending stress to a maximum of 10,000 psi. Design in accordance with the provisions of Chapter 7 of AWWA M-11.

4. Design reinforcement for wyes, tees, outlets, and nozzles in accordance with AWWA Manual M-11, for the allowable stresses as specified in 2.02.C.2, and in accordance with the details shown.
5. In lieu of saddle or wrapper reinforcement for outlets as provided by the design procedure in Manual M-11, pipe or specials with outlets may be designed in their entirety of steel plate having a thickness equal to the sum of the pipe wall plus the required reinforcement.
6. Furnish crotch-plate reinforcement where required by the M-11 design procedure.

2.03 STEEL PIPE, FITTINGS, AND SPECIALS MATERIALS

A. Straight Pipe Cylinder:
   1. Steel coils for spiral welded steel pipe or steel sheet or plate for straight seam welded steel pipe per AWWA C200 and as follows:
      a. Steel Sheet:
         1) ASTM A1008/A1008M: SS Grade 36 Type 1, SS Grade 40 Type 2, or SS Grade 50
      b. Steel Plate:
         1) ASTM A36
         2) ASTM A283 Grades C or D
         3) ASTM A516 Grade 70
         4) ASTM A572 Grade 42
         5) Fully-killed plate conforming to ASTM A20, fine grained practice.
         6) Normalize steel plates that are ¾-inch thick or greater.
      c. Steel Coil:
         1) ASTM A139 Grade B or C
         2) ASTM A1011/A1011M: SS Grade 40, or SS Grade 45
         3) A1018/A1018M, SS Grade 36 Type 2, or SS Grade 40.
         4) Continuous cast process, fully-killed, fine grained practice.
   2. Maximum carbon content of 0.25 percent and a maximum carbon equivalent of 0.45 calculated as follows:

      $$CE=C+(Mn+Si)/6+(Cr+Mo+V)/5+(Ni+Cu)/15$$

   3. Minimum elongation of 22 percent in a 2-inch gage length.
   4. Toughness: Test all steel 0.500-inch or greater in thickness for notch toughness using the Charpy V-Notch test. Use transverse specimen orientation and full-size specimens for testing. Steel shall withstand a minimum impact of 25 ft-lb. energy at a test temperature of 30 degrees Fahrenheit.
   5. Wall Thickness: The maximum allowable thickness variation for steel sheet, plate, or coil shall have a zero (0) negative thickness tolerance from nominal calculated, specified, or shown.
   6. Threaded outlets: Forged steel suitable for 3,000 psi service as manufactured by Vogt or approved equivalent.

B. Fittings and Specials:
   1. Fabricate from straight pipe cylinder materials as specified in 2.03.A. and in full conformance with the design criteria specified in 2.02.C and dimensions of AWWA C208, unless otherwise indicated.
   2. Outlets:
      a. Outlets 12-inch and smaller may be fabricated from Schedule 40 or heavier steel pipe in the standard outside diameters, i.e., 12-3/4-inch, 10-3/4-inch, 8-5/8-inch, 6-5/8-inch, and 4-1/2-inch.
      b. Outlets greater than 12-inch diameter and up to and including 24-inch diameter: Fabricate from ASTM A53/A53M, Type E or S, Grade B, standard weight steel pipe.
      c. Outlets larger than 24-inch diameter: Fabricate from same steel as specified for straight pipe cylinder.
   3. Collar or wrapper reinforcement: Fabricate collar or wrapper reinforcement using the steel as specified for straight pipe cylinder.
   4. Crotch Plate: Fabricate from fully killed, fine grain, pressure vessel steel conforming to ASTM A516/A516M, Grade 70, and as follows:
      a. Plates shall be normalized.
      b. Sulfur content shall not exceed 0.005 percent. Carbon shall not exceed 0.20 percent. Manganese shall not exceed 1.20 percent.
      c. Charpy V-notch tests in direction transverse to final rolling shall be performed per ASTM A370 on full size specimens of coupons taken from each plate. Acceptance shall be 25 foot-pounds at 30 degrees F.
      d. Carbon equivalent shall not exceed 0.45 percent.
   5. Steel Butt-Weld Fittings:
      a. 24 Inches and Smaller: In accordance with ANSI B16.9 conforming to ASTM A234/A234M.
      b. Standard weight.
      c. Taper pipe wall at welds at 4:1 for connection to pipe of different wall thickness.
   6. Coordinate difference in diameter convention between specials and AWWA C200/C208 pipe and fittings to provide complete piping system as shown.

2.04 STEEL PIPE, FITTINGS, AND SPECIALS DESIGN AND FABRICATION

A. Steel Pipe:
   1. General:
      a. Furnish steel pipe with shop-lined cement mortar, shop-coated tape or polyurethane, and rubber-gasketed or field-welded joints as shown.
      b. The pipe shall be designed, manufactured, tested, inspected, and marked according to applicable requirements previously stated and except as hereinafter modified, shall conform to ANSI/AWWA C200.
      c. Pipe Dimensions: The pipe shall be of the nominal inside diameter including the lining. The minimum steel cylinder thickness for each pipe size shall be as specified or shown.

2. Shop Welding:
   a. All longitudinal and girth seams, whether straight or spiral, shall be complete joint penetration (CJP) butt welded using an approved electric-fusion-weld process.
   b. Lengths of pipe shall not be shop-joined using lap joints.
   c. When using straight seams, fabricate pipe with either a single longitudinal seam and multiple courses of from 7 feet 6-inches to 10 feet, or else with a single course having not more than the number of longitudinal seams shown in the table listed below. Where more than one longitudinal seam is used, the plates shall be of equal widths. Equally stagger the longitudinal joints of adjacent courses. When using spiral seams, coil splices shall be a minimum of 2 feet away from the ends of the pipe cylinder.

Pipe Nominal Diameter (inches)	No. of Seams
24 to 60	2
61 to 90	3
91 to 120	4

   d. All longitudinal and coil splice weld seams on pipe surfaces that will have a flexible tape coating shall be ground to provide a smooth surface. The resulting weld surface shall have a cross-section shape that is free is discontinuities, abrupt changes in curvature, with no ridges or valleys that may promote bridging or disbondment of the tape from the substrate. Polyurethane-coated pipe only requires grinding in areas for joint engagement. Special care shall be exercised so that grinding into parent metal does not occur.
   e. Weld Stripping Tape: For flexible coating, if the spiral weld height is greater than 3/32-inch and/or the weld surface cross-section shape has significant discontinuities including abrupt changes in curvature, ridges or valleys that may promote bridging or disbondment of the tape from the substrate, then weld stripping tape, 6-inches wide, shall be applied over all exterior spiral welds with the exception of approved hold back areas. The tape shall be applied with the center of the tape at the weld. Application of the weld stripping tape shall be such that the tape is completely pressed into the edge of the weld. The stripping tape application will be followed by a conformable roller applying sufficient pressure to achieve this requirement.
3. Moderate Deflections/Long Radius Curves:
   a. Moderate deflections and long radius curves may be designed by means of mitered ends, by pulling standard joints, by using short lengths of pipe, or a combination of these methods.
   b. Pulled joints shall not be used in combination with mitered ends.
   c. Mitered ends shall only be used with lap welded joints, unless specifically approved in writing by Engineer.
   d. Provide miter-cut that is cold expanded square with face of miter.
   e. The maximum total allowable angle for mitered joints shall be 5 degrees per pipe joint.

f. Miters shall be provided on bell ends. Mitering of the spigot ends will not be permitted.
g. The maximum allowable angle for pulled joints shall be the angle generated by 75 percent of the manufacturer's recommended pull.
h. All horizontal deflections or fabricated angles shall fall on the alignment. In congested city streets or at other locations where underground obstructions may be encountered, the chord produced by deflecting the pipe shall be no further than 12 inches from the alignment shown.
i. All vertical deflections shall fall on the alignment and at locations adjacent to underground obstructions, points of minimum earth cover, and pipeline outlets and structures, the pipe angle points shall match the angle points shown.

B. Steel Fittings and Specials:
1. General:
a. Shop fabricated. No field fabrication will be accepted unless approved by Engineer.
b. Specials and fittings shall be equal or greater in pressure design strength and shall have the same lining and coating as the adjoining pipe.
c. Fitting Dimensions: The fittings shall be of the same nominal inside diameter as the adjoining pipe with dimensions per AWWA C208.
d. Fittings may be fabricated from pipe that has been mechanically lined and/or coated. Areas of lining and coating that have been damaged by such fabrication shall be repaired by hand-applications in accordance with this specification and applicable AWWA or ASTM Standards.
2. Fittings/Elbows:
a. Unless otherwise shown, the minimum radius of elbows shall be 2.5 times the pipe diameter.
b. If the radius cannot be maintained at a minimum of 2.5 times the pipe diameter, the minimum bend wall thickness shall be the greater of the value specified in 2.02.C.3 or as calculated using the equations in Chapter 9 of AWWA M11.
c. The maximum miter angle shall be 11-1/4 degrees on each section resulting in a maximum deflection angle of 22.5 degrees per miter weld as recommended in AWWA C208.
d. Complete joint penetration (CJP) welds on miter welds.
3. Reinforcement for wyes, tees, outlets, and nozzles shall be designed in accordance with AWWA Manual M-11. Reinforcement shall be designed for the design pressure specified or shown and shall be in accordance with the details shown. The test pressure shall be used as the design pressure for determining required reinforcement type.
4. In lieu of collar reinforcement, pipe, fittings, or specials with outlets may be fabricated in their entirety of steel plate having thickness equal to sum of pipe wall plus required reinforcement.
5. Unless otherwise shown, outlets 2 inches in diameter and smaller need not be reinforced.
6. Where required by the M-11 design procedure, crotch plate reinforcement shall be furnished. Test pressure shall be used as design pressure.

7. Access manholes with covers shall be as per required outlet design and as detailed.

2.05 JOINT DESIGN AND FABRICATION

A. General: The standard field joint for non-restrained steel pipe, with a maximum of 250 psi or less, shall be as follows:

Nominal pipe diameter	Standard Field Joint
54-inch or less	Rubber gasketed bell-and-spigot
54-inch - 78-inch	Single lap welded
Greater than 78-inch	Double lap welded

B. Single or double lap welded joints shall be provided where shown or required. Mechanically coupled, or flanged joints shall be required where shown. Butt-strap joints shall be used only where required for closures or where shown. Double welded lap joints and butt-strap joints shall be tapped and drilled for air testing in accordance with AWWA C206. Joints shall be tapped in the bell end. The joints furnished shall have the same or higher pressure rating as the adjoining pipe.

C. Bell-and-Spigot with Rubber Gaskets:
   1. Manufactured in accordance with AWWA C200.
   2. For bell-and-spigot ends with rubber gaskets, the clearance between the bells and spigots shall be such that when combined with the gasket groove configuration and the gasket itself, it will provide watertight joints under all operating conditions when properly installed. The Contractor shall require the pipe manufacturer to submit details complete with significant dimensions and tolerances and also to submit performance data indicating that the proposed joint has performed satisfactorily under similar conditions. In the absence of a history of field performance, the results of a test program shall be submitted.
   3. Unless otherwise approved by the Engineer, bell ends shall be formed by an expanding press or by being moved axially over a die in such a manner as to stretch the steel cylinder beyond its elastic limit to form a truly round bell of suitable diameter and shape. No process will be permitted in which the bell is formed by rolling.

D. Single or Double Welded Lap Joints:
   1. Joints prepared for field welding shall be in accordance with ANSI/AWWA C200. Minimum lap shall be 2-inches for single lap weld and 3-inches for double lap weld. The minimum flat bell length shall be 2 inches longer than the standard lap.
   2. The method used to form, shape and size bell ends shall be such that the physical properties of the steel are not substantially altered. Unless otherwise approved by the Engineer, bell ends shall be formed by an expanding press or by being moved axially over a die in such a manner as to stretch the steel plate beyond its elastic limit to form a truly round bell of suitable diameter and shape.

3. No process will be permitted in which the bell is formed by rolling. Faying surfaces of the bell and spigot shall be essentially parallel, but in no case shall the bell slope vary more than 2 degrees from the longitudinal axis of the pipe.
4. Temperature Control Lap Joint: Provide a special longer bell end (temperature control lap joint) at a maximum spacing of 300 feet to account for movement of the installed pipe due to temperature changes. The pipe manufacturer shall determine the length required for the longer bell. Minimum temperature control lap joint length is as shown on the Drawings.

E. Butt-Strap Joints:
1. Minimum lap shall be 2-inches for single lap weld and 3-inches for double lap weld.

F. Full-Penetration Butt Welds:
1. Plain ends beveled as required by AWWA C200 and Contractor's field WPS.

G. Restrained Joints:
1. Where shown, restrained joints shall be field-welded lap. Designs shall include considerations of stresses induced in the steel cylinder, and any field welds caused by thrust at bulkheads, bends, reducers, and line valves resulting from the design working and test pressures.
2. For field welded joints at design working pressure, design stresses shall not exceed 67 percent of the specified minimum yield strength of the grade of steel utilized for the part being examined when longitudinal thrust is assumed to be uniformly distributed around the circumference of the joint.
3. For field welded joints at design test pressure, design stresses shall not exceed 75 percent of the specified minimum yield strength of the grade of steel utilized for the part being examined when longitudinal thrust is assumed to be uniformly distributed around the circumference of the joint.

H. Joints Within Casing or Concrete Encasement: All joints located within a casing or concrete encasement shall be double lap welded or full-penetration butt welded, as required.

I. Shop-applied interior linings and exterior coatings shall be held back from the ends of the pipe as shown or as otherwise acceptable to the Engineer. For tape coating all welds on the exterior of spigots shall be ground smooth for a distance of 18 inches from pipe ends. For other coatings and linings, all welds shall be ground smooth for the engagement length of the joint plus 2 inches minimum.

2.06 FLANGED JOINTS

A. Flanges:
1. Flanges shall be made from seamless forgings, cut from plate as a single piece, welded bar rings, or segmented and welded plates. Flanges shall be flat-faced carbon steel or alloy flanges in full conformance with AWWA C207.

2. The manufacturer shall provide mill test reports showing conformance to the physical and chemical requirements.
3. Boltholes shall straddle the vertical axis of the pipe unless otherwise shown.
4. Attachment of the flanges to the pipe shall conform to the applicable requirements of AWWA C207.
5. Flanges for miscellaneous small pipes shall be in accordance with the standards specified for these pipes.
6. Do not expose AWWA flanges to test pressures greater than 125 percent of rated capacity. For higher test pressures, use next higher rated AWWA flange or ANSI-rated flange.
7. Maximum allowable flange pressure ratings are as follows:

Flange Type	Maximum Allowable Pressure (psi)	
	Working	Test
AWWA C207		
Class B	86	107
Class D		
1-12 inches	175	218
14-144 inches	150	188
Class E	275	343
Class F	300	375
ANSI B16.5/B16.47		
Class 150	275	275
Class 300	720	720

B. Flange Bolts:
   1. Bolts for flanged connections shall be carbon steel, galvanized, ASTM A307, Grade A hex bolts with ASTM A563, Grade A hex nuts for class B and D flanges, unless otherwise indicated.
   2. Bolts for class E and F flanges shall be ASTM A193 grade B7 with ASTM A194 grade 2H heavy hex nuts.
   3. Bolts shall have regular unfinished square or hexagonal heads, and nuts shall have regular square or hexagonal dimensions, all in accordance ANSI B18.2.1 for wrench head bolts and nuts and wrench openings.
4. Studs and bolts shall extend through the nuts a minimum of 1-inch. All-thread studs shall be used on all valve flange connections, where space restrictions preclude the use of regular bolts.

C. Flange Gaskets: Non-asbestos type and in conformance with AWWA C207.

D. Blind Flanges: Blind flanges shall be in accordance with ANSI/AWWA C207, or with the standards for miscellaneous small pipes. All blind flanges for pipe sizes 12 inches and over

shall be provided with lifting eyes in the form of welded or screwed eyebolts; or an approved alternative.

E. Flange Coating: All machined faces of metal blind flanges and pipe flanges shall be coated with a temporary rust-inhibitive coating to protect the metal until the installation is completed.

F. Flange classifications indicated to match design pressure rating of pipe or where specified in the Drawings.

G. Insulating Flange Kits:
1. Insulating flange sets shall be provided where shown.
2. Dielectric flange kit materials shall consist of full faced gaskets, bolt sleeves, non-metallic washers, and steel backing washers.
3. Gaskets shall be "Type E" (full face) phenolic with a Buna-N o-ring type sealing element.
4. Insulating bolt sleeves shall be the single one-piece sleeve and washer type made of Minlon or acetal resin plastic, shall fit within the bolt facing of the flange, and shall allow the standard size bolt or stud for the flange to be inserted.
5. The steel backing washers shall be 1/8" thick, cadmium plated, hot rolled steel and shall fit within the bolt facing on the flange.

2.07 WELD LEADS/PASS HOLE OUTLETS

A. Outlets for welding leads or pass holes, if used, shall be determined by installation contractor. The number and locations of these outlets shall be at the Contractor's option and shall be indicated on the Shop Drawings.

B. Plugs used for closing the weld lead outlets shall be suitable for the internal pressure and allow zero leakage. Weld plugs closed after completion of work.

2.08 LININGS

A. Shop Applied Cement-Mortar Lining:
1. Notify Engineer at least 5 days prior to application of lining products.
2 Cement: Cement for mortar shall conform to the requirements of AWWA C205, provided that cement for mortar lining shall be Type II, Type II-Modified, or Type V. A fly ash or pozzolan shall not be used as cement replacement.
3. Except as noted on the drawings or noted herein, interior surfaces of all steel pipe, fittings, and specials shall be cleaned and lined in the shop with cement-mortar lining applied centrifugally in conformity with ANSI/AWWA C205.
4. The minimum lining thickness shall be as follows, with a tolerance of plus 1/8-inch or minus 1/16-inch:

Nominal Pipe Diameter (in)	Lining Thickness (in)
4-10	1/4
11-23	5/16
24-36	3/8
over 36	1/2

5. The lining machines shall be of a type that has been used successfully for similar work and shall be approved by the Engineer.
6. During the lining operation and thereafter, the pipe shall be maintained in a round condition by suitable bracing or stulling.
7. Every precaution shall be taken to prevent damage to the lining. If lining is damaged or found faulty at delivery site, the defective linings or unsatisfactory portions, as determined by AWWA C205 or the Engineer, shall be removed from the pipe wall and shall be replaced to the full thickness required at no additional cost to the Owner. Defective linings shall be cut back to a square shoulder in order to avoid feather edged joints.
8. The progress of the application of mortar lining shall be regulated in order that all hand work, including the repair of defective areas is cured in accordance with the provisions of ANSI/AWWA C205. Cement-mortar for patching shall be the same materials as the mortar for machine lining, except that a finer grading of sand and mortar richer in cement shall be used when field inspection indicates that such mix will improve the finished lining of the pipe.
9. Specials and fittings that cannot be mechanically-lined shall be lined by hand-application, using the same materials as are used for the pipe and in accordance with the applicable AWWA C205 or ASTM Standards. Lining applied in this manner shall provide protection equal to that specified for the pipe.
10. Shop-applied interior linings shall be held back from the ends of the pipe where field joints occur as shown or as otherwise acceptable to the Engineer. Ends of the linings shall be left square and uniform. Feathered or uneven edges will not be permitted.
11. Protection of Pipe Lining/Interior: For all pipe and fittings with plant-applied concrete or cement mortar linings, the Contractor shall provide a polyethylene or other suitable bulkhead on the ends of the pipe and on all special openings to prevent drying out of the lining. All bulkheads shall be substantial enough to remain intact during shipping and storage until the pipe is installed.

B. Field-Applied Cement-Mortar Lining:
   1. Materials and design of in-place cement-mortar lining shall be in accordance with AWWA C602.
   2. Do not use pozzolanic material in mortar mix.
   3. Admixtures shall contain no calcium chloride.
   4. Wire mesh reinforcement required in the lining of specials shall be provided and installed in accordance with AWWA C205.

C. Liquid Epoxy Lining

1. Spray Applied Liquid Epoxy Lining: Interior surfaces of steel pipe, fittings, and specials, shall be cleaned and lined in the shop with spray applied high build polyamide liquid epoxy per the following:
2. Minimum total dry film thickness of 16 mils and a maximum total dry film thickness of 25 mils. Comply with all sections of AWWA C210 and NSF 61 for potable water contact.
3. Near white blast (SSPC-SP10) surface preparation prior to coating.
4. Apply per manufacturers instructions. No single coat shall be applied at a thickness exceeding the manufacturer's requirements.
5. Cure lining for 7 days prior to installation.

D. Polyurethane Lining

1. Self-priming, plural component, 100 percent solids, polyurethane lining system, suitable for immersion, in accordance with AWWA C222.
2. NSF 61 approved for potable water contact.
3. Near white blast (SSPC-SP10) surface preparation prior to coating.
4. Apply per manufacturers instructions to a minimum dry film thickness of 25 mils.

2.09 COATINGS

A. General:

1. Notify Engineer at least 5 days prior to application of coating products.
2. Exterior Coating of Exposed Piping: The exterior surfaces of pipe which will be exposed to the atmosphere inside structures or above ground shall be thoroughly cleaned and then given a shop coat of rust-inhibitive primer conforming to the requirements of Section 09810.
3. Unless otherwise shown, exterior surfaces of pipe or fittings passing through structure walls shall be coated as follows based on the type of wall penetration:
   a. Wall flange: Terminate coating to the outside bottom edge of wall flange. Do not coat weep ring.
   b. Modular mechanical type: Terminate coating at a point 1-inch inside the interior edge of the vault wall.
4. Holdback of coating from field-welded joints shall be as follows:
   a. For lap welded joints and flex couplings, 8 inches.
   b. For butt weld and butt strap joints, 6 inches.
5. Furnish inspection devices that are calibrated and in good working condition for detection of holidays and measurement of coating film thickness and adhesion testing.

B. Coating System: For the exterior coating of buried piping, provide one coating system from the following options:

1. Prefabricated multi-layer cold-applied tape coating of pipe for buried service shall be applied in accordance with AWWA C209 and AWWA C214 as modified herein and in Section 09810.

2. Polyurethane coating in accordance with AWWA C222 as modified herein and in Section 09910.
3. Field joints and fittings and specials that cannot be machine coated in accordance with the above systems shall be coated with a heat-shrinkable cross-linked polyolefin coating in accordance with AWWA C216 and Section 09810 – Pipeline Tape Coating.

2.10 SOURCE QUALITY CONTROL (PIPE MANUFACTURING)

A. Crotch Plate:
1. Through-Thickness tension testing shall be performed with acceptance criteria per Article 5 of ASTM A770/A770M on each plate.
2. Straight-Beam Ultrasonic Examination shall be conducted with acceptance criteria per Article 6 of ASTM A435/A435M on each plate.
3. Plates that do not qualify shall not be used.

B. Shop Hydrostatic Pressure Test: In accordance with AWWA C200 Section 5.2, except as follows:
1. General: Unless specified otherwise, testing of pipe, fittings, and specials shall be performed before lining and coating is applied.
2. Each length of pipe of each diameter and pressure class shall be shop-tested and certified to a pressure of at least 75 percent of the yield strength of the pipe steel.
3. Fittings and Specials:
   a. If fabricated from untested straight pipe, test to minimum pressure equal to field test pressure.
   b. Except as otherwise specified herein, no additional shop hydrostatic test will be required on fittings and specials fabricated from successfully tested straight pipe and where new welds are tested as specified.
   c. Hydrostatically test fittings and specials with crotch plates, regardless of whether or not straight pipe sections used were previously tested.

C. Shop Nondestructive Testing:
1. Welds: 100 percent visually examined by CWI per ASME BPVC SEC VIII, Division 1.
2. Butt-Joint Welds: 100 percent ultrasonically examine welds or spot radiographically examine pipe in accordance with ASME BPVC SEC VIII, Div. 1.
3. Fillet Welds: 100 percent examine using dye penetrant or magnetic particle inspection method in accordance with ASME BPVC SEC VIII, Division 1.
4. Groove Welds: 100 percent ultrasonically examine welds or spot radiographically examine pipe in accordance with ASME BPVC SEC VIII, Div. 1.
5. Air test collars and wrappers in accordance with AWWA C206.

2.11 COUPLINGS

A. Sleeve Type, Flexible Couplings:
1. Pressure and Service shall be the same as connected piping.
2. Materials: Steel.

3. Gaskets: Suitable for specified service.
4. Bolts and Nuts: Alloy steel, corrosion-resistant, prime coated. Buried couplings shall have Type 316 stainless steel bolts and nuts.
5. Harnessing:
   a. Harness all couplings to restrain all pressure piping.
   b. Dimensions, sizes, spacing and materials for lugs, tie bolts, washers, and nuts shall conform to the standards of the manufacturer for the pipe size, wall thickness and working pressure required.
   c. No less than two bolts shall be furnished for each coupling.
   d. Flexible couplings for flanged steel pipe shall be harnessed with tie bolts and lugs conforming to AWWA Manual M11 "Steel Pipe Design and Installation."
   e. Lugs shall be fabricated from steel equal to or better than that specified for the pipe to be harnessed. The lugs shall be shop welded to the pipe.
   f. Lugs and tie bolts shall be designed for the pipeline test pressure.
   g. Tie bolts, nuts and washers shall be ASTM A 193, Grade B7 steel or better.
6. Product and Manufacturer: Provide one of the following:
   a. Dresser Industries, Style 38.
   b. Rockwell International Corporation.
   c. Or Equal.

B. Flanged Adapters:
1. Pressure and Service shall be the same as connected piping.
2. Materials: Steel.
3. Bolts and Nuts: Alloy steel, corrosion-resistant. Buried adapters shall have Type 316 stainless steel bolts and nuts.
4. Harnessing: Flanged coupling adapters for steel pipe shall be harnessed by using tie bolts and lugs as specified for flexible couplings.
5. Product and Manufacturer: Provide one of the following:
   a. Dresser Industries Style 128.
   b. Viking-Johnson.

2.13 UNDERGROUND MARKING TAPE

A. Marking tape shall be 6-inches wide, blue background in color, with the following black lettering "CAUTION WATER LINE BURIED BELOW". Marking tape shall be Empire Level Shieldtec or approved equivalent.

2.14 PIPELINE LINE MARKERS

A. Furnish pipeline line markers. Markers shall be carsonite, curv-flex, 66-inch in length, and blue for water lines. Affix adhesive decal onto each marker supplied by the marker post manufacturer with the following lettering:
1. "CAUTION – WATER PIPELINE; BEFORE DIGGING CALL CITY OF PHOENIX WATER SERVICE DEPARTMENT"

PART 3 - EXECUTION

3.01 GENERAL

A. Delivery, Handling, and Storage:
   1. All pipe, fittings, etc., shall be carefully handled and protected against damage to lining and coating interior and exterior surfaces, impact shocks, and free fall. All pipe handling equipment shall be acceptable to the Engineer. Pipe shall not be placed directly on rough ground but shall be supported at 1/3 and 2/3 points along the length of the pipe section in a manner which will protect the pipe against injury whenever stored at the trench site or elsewhere. Pipe shall be handled and stored at the trench site in accordance with the Paragraph in Part 1 entitled "Produce Handling, Delivery, and Storage." No pipe shall be installed where the lining or coating surfaces show cracks or other defects that may be harmful as determined by the Engineer. Such damaged lining and/or coating surfaces shall be repaired, or a new undamaged pipe shall be furnished and installed.
   2. Repair or replace damaged pipe fittings, specials, and appurtenances.
   3. The Contractor shall inspect each pipe and fitting to insure that there are no damaged portions of the pipe. The Contractor shall remove or smooth out any burrs, gouges, weld splatter or other small defects prior to laying the pipe.
   4. Before placement of pipe in the trench, each pipe or fitting shall be thoroughly cleaned of any foreign substance, which may have collected thereon and shall be kept clean at all times thereafter. For this purpose, the openings of all pipes and fittings in the trench shall be closed during any interruption to the Work until final fit-up.
   5. Lifting points shall be no closer than the 1/3 and 2/3 points along the length of the section. Select lifting points that do not result in damage to the pipe. The pipe shall be handled using two minimum 12-inch wide belt slings attached to a spreader bar, unless otherwise approved by the Engineer. Do not use cable slings or chains. Avoid damage to coating and lining.
   6. Stulls installed by manufacturer shall remain in place throughout all delivery, handling, storage, installation, and backfill operations, unless otherwise approved by the Engineer. Stulls shall be left in place until the joints at each end have been completed and embedment and backfill for the section have been placed to at least 12 inches above the top of the pipe. Final inspection, repair, and checking of interior lining shall be performed after the struts have been removed.
   7. Pipe and Specials Protection: Protect with suitable bulkheads the openings of pipe and specials where the pipe and specials have been cement-mortar lined in the shop to maintain a moist atmosphere and to prevent unauthorized access by persons, animals, water or any undesirable substance. Design the bulkheads to prevent drying out of the interior of the pipe up to installation. Maintain bulkheads, fix tears or replace bulkheads damaged. Introduce water into the pipe to keep the mortar moist where moisture has been lost due to damaged bulkheads.

B. Straight pipe, bends, tees, adapters, access manholes, closure pieces, blowoff fittings, caps and plugs necessary for testing, and other fittings or specials shall be furnished as indicated

on the Drawings or as required to complete the Work. Install piping complete with jointing materials and accessories, anchors, and other appurtenances.

C. The pipe manufacturer's representative shall furnish for submittal a written report of each site visit.

3.02 PIPE INSTALLATION

A. General:
   1. When the pipe is being installed, it shall be turned and placed where possible, so that any slightly damaged portion will be on top. The damaged area shall be repaired for the protection of any exposed steel. All damaged areas shall be repaired using materials and methods acceptable to the Engineer.
   2. Each section of pipe shall be laid in the order and position shown on the laying schedule. Lay pipe to the set line and grade. On grades of zero (0) slope, the intent is to lay to grade. Installation tolerances shall be as hereinafter specified. All fittings, bends, and specials shall be properly installed as shown.
   3. Except for short runs which may be permitted by the Engineer, pipes shall be laid uphill on grades exceeding 10 percent. Pipe which is laid on a downhill grade shall be blocked and held in place until sufficient support is furnished by the following pipe to prevent movement.
   4. Make minor field adjustments by pulling standard joints.
      a. Maximum Allowable Angle: 75 percent of manufacturer's recommended pull.
      b. Maximum Allowable Gap: 1/8 inch between bell and spigot at weld location.

B. Trenching, embedment, and backfilling of buried piping shall conform to Section 02315 – Structural Excavation and Backfill and to the details indicated on the Drawings. Do not install pipe in the trench until groundwater has been mitigated and the pipe subgrade has been properly stabilized.

C. Placement of Pipe in Trench:
   1. Pipe shall be laid directly on the imported bedding material. No blocking will be permitted, and the bedding shall be such that it forms a continuous, solid bearing for the full length of the pipe.
   2. Where CLSM is to be used for pipe bedding or where allowed by the Engineer, pipe may be installed directly on moist sand bag supports. Place sand bag supports to provide at least 6-inches of CLSM below bottom of pipe. Space supports at a maximum interval of 10 feet and one set within 3 feet on both sides of each joint. Provide additional sand bags as needed to support pipe on line and grade.
   3. Excavations shall be made as needed to facilitate removal of handling devices after the pipe is laid.
   4. Bell holes shall be formed at the ends of the pipe to prevent point loading at the bells or couplings. Excavation shall be made as needed outside the normal trench section at field joints to permit adequate access to the joints for field connection operations and for application of coating on field joints.

5. Where necessary to raise or lower the pipe due to unforeseen obstructions or other causes, the Engineer may change the alignment and/or the grades. Such change shall be made by the deflection (pulling) of joints, adapters, or by the use of additional fittings. The allowable deflection of field joints is described in Subparagraph 3.02.A.4. No joint shall be misfit any amount which will be detrimental to the strength and water tightness of the finished joint. In all cases the joint opening, before finishing with the protective mortar inside the pipe, or prior to applying in-place mortar lining, shall be the controlling factor.
6. Alignment and Grade:
    a. High points which allow air to collect in pipelines are not acceptable unless an air release valve is indicated on the Drawings at that location.
    b. Survey equipment shall be used to indicate alignment and grade. Take at least one elevation reading on each length of pipe. Make periodic elevation measurements with surveying instruments to verify accuracy of grades.
    c. Verify survey set up at least daily using an independent benchmark or temporary benchmark.
    d. Alignment and Grade Tolerances:
        1) Plus or minus 0.05 foot in grade (vertical). High points will not be acceptable, except where indicated on the Drawings.
        2) Plus or minus 0.20 foot in alignment (horizontal).
7. At all times, means shall be provided to prevent the pipe from floating. Closely follow the installation and jointing of steel pipe with pipe embedment and backfilling to prevent flotation of the pipe by water and longitudinal movement caused by thermal expansion or contraction of the pipe. The backfill adjacent to field joints may be temporarily omitted to provide adequate space for field coating the joints.
8. Check each joint, including restrained joints, as recommended by the pipe manufacturer's field service representative, to determine that the joint and the restraints are installed properly.
9. Whenever pipe laying is stopped, seal the open end of the line with a plug. Water shall be removed from the trench to the level as indicated in Section 02315 – Structural Excavation and Backfill prior to removing the plug.
10. Out-of-Round Pipe: Pipe that deviates from a true circle by more than 1 percent shall be laid with its larger diameter vertical, or by using struts on continuous head and sill timbers to correct the vertical diameter where acceptable to the Engineer.
11. Pipe Deflection: After completion of backfilling and before acceptance of the Work, test for excessive deflection on pipes larger than 30 inches in diameter by measuring the actual inside vertical diameter. Deflection measurements will be made by the Engineer. Pipe diametral deflection shall not exceed the allowable measured in the vertical orientation and at any point in the pipe. Correct diametral deflection to less than allowable.
12. Pipe Cleanup: As pipe laying progresses, the Contractor shall keep the pipe interior free of all debris. The Contractor shall completely clean the interior of the pipe of all sand, dirt, mortar splatter and any other debris following completion of pipe laying, pointing of joints, and any necessary interior repairs prior to testing and disinfecting the completed pipeline.

3.03 PIPE JOINTING

A. Rubber Gasketed Joints:
   1. Immediately before jointing pipe, the spigot end of the pipe shall be thoroughly cleaned, and a clean rubber gasket lubricated with an approved vegetable-based lubricant shall be placed in the spigot groove.
   2. The volume of the gasket shall be "equalized" by moving a metal rod between the gasket and the spigot ring around the full circumference of the spigot ring.
   3. The bell of the pipe already in place shall be carefully cleaned and lubricated with a vegetable-based lubricant. The spigot of the pipe section shall then be inserted into the bell of the previously laid joint and telescoped into its proper position.
   4. After the pipe units have been joined, a feeler gage shall be inserted into the recess and moved around the periphery of the joint to detect any irregularity in the position of the rubber gasket. If the gasket cannot be "felt" all around, the joint shall be disassembled. If the gasket is undamaged, as determined by the Engineer, it may be reused, but only after the bell ring and gasket have been re-lubricated.

B. Welded Joints:
   1. Welds shall be sound and free from embedded scale or slag, shall have tensile strength across the weld not less than that of the thinner of the connected sections, and shall be watertight. Field-welded joints shall be either welded butt strap joints, welded butt joints, or welded lap joints and shall conform to AWS D1.1, AWWA C206, approved welding procedures, and referenced welding codes. In case of conflict, AWS D1.1 shall govern.
   2. Determine preheat and interpass temperature requirements for unlisted base metals according to AWS D1.1, Annex XI guideline on Alternative Methods for Determining Preheat.
   3. Repair, redo, and retest rejectable weld defects until sound weld metal has been deposited in accordance with appropriate welding codes.
   4. Where exterior welds are performed, provide adequate space for welding and inspection of the joints.
   5. When fitting up the ends of pipe to be welded or fitting butt-strap pieces, minor jacking or clamping will be allowed. Cold working the metal with sledges or localized application of heat and working the metal with sledges will not be allowed. If field displacement of joints, where butt strap joints are indicated, does not allow proper fit up with the tolerances indicated, special closure butt straps or mitered pieces shall be shop fabricated and installed.
   6. During installation of welded steel pipe in either straight alignment or on curves, the pipe shall be laid so that at any point around the circumference of the joint there is a minimum lap of 1/2-inch and a minimum space of 3/4-inch plus the thickness of the steel pipe wall between the spigot end of the pipe and the nearest tangent to a bell radius.
   7. An 18-inch minimum wide strip of heat resistant material shall be draped over the top half of the pipe on each side of coating holdback during welding to avoid damage to the

coating by hot weld splatter. Welding grounds shall not be attached to the coated part of the pipe.

8. After the pipe and pipe joint are properly positioned in the trench, the length of pipe between joints shall be backfilled to at least one foot above the top of the pipe. Care shall be exercised during the initial backfilling to prevent movement of the pipe and to prevent any backfill material from being deposited on the joint.
9. Control of Temperature Stresses:
    a. Control temperature stresses in accordance with AWWA C206, the submitted and accepted temperature stress control submittal, and these Specifications. Provide special temperature control lap joints at intervals of 300 feet or less, unless otherwise approved by the Engineer.
    b. The unbackfilled joint areas of the pipe shall be shaded from the direct rays of the sun by the use of properly supported awnings, umbrellas, tarpaulins, or other suitable materials for a minimum period of 2 hours prior to the beginning of the welding operation and until the weld has been completed. Shading materials at the joint area shall not rest directly on the pipe but shall be supported to allow air circulation around the pipe. Shading of the pipe joints need not be performed when the ambient air temperature is below 50 degrees F.
    c. Supply a special temperature control lap joint at intervals not exceeding 300 feet along welded reaches of the pipeline, at the first regular lap-welded field joints outside concrete encasements and structures, and where shown. Lay joint with an initial lap of not less than 3 inches greater than the typical lap joint. Where temperature control lap joints occur in a traveled roadway or other inconvenient location, the location of the joint may be adjusted, as acceptable to the Engineer.
10. Prior to beginning the welding procedure, remove any tack welds used to position the pipe during laying. Equally distribute any annular space between the fraying surfaces of the bell and spigot around the circumference of the joint by shimming, jacking, or other suitable means. The weld shall then be made in accordance with ANSI/AWWA C206. Where more than one pass is required, each pass except the first and final one shall be peened to relieve shrinkage stresses; and all dirt, slag, and flux shall be removed before the succeeding bead is applied.
11. The pipe ends shall be cut straight on joints where butt straps are used for realignment, adjustment, or deflection, and fillet welds shall be made as shown. Beveled ends for butt welding shall conform to ANSI B16.25. Contractor shall provide an automated machine for field mitering beveled ends for butt welding.
12. Field-welded lap joints shall be full fillet welds on the inside and/or outside of the joint.
13. Welded Butt Joints: Where used or required, shall be complete joint penetration and as indicated. Prior to butt welding, the pipe and pipe joint shall be properly positioned in the trench using line up clamps so that, in the finished joint, the abutting pipe sections shall not be misaligned by more than 1/16-inch.
14. Welded Butt Straps: Where used or required, shall be a minimum of 12 inches wide, the same thickness as the pipe wall and shall provide for a minimum of 3-inch lap at each pipe joint.

C. Welding Procedures:

1. Upon completion of each field-welded joint, mark the welder's identification number and the last two digits of the year the Work was completed or the Contractor may have a records system that traces a welder's work. Steel stamping directly on piping will not be acceptable unless "low stress" die stamps, such as interrupted dot or round-nose types, are used.

D. Inspection and Testing of Field Welded Joints
   1. All field butt welds shall be inspected as soon as practicable after the welding of the field joint is completed. The CONTRACTOR shall inspect the joint by ultrasonic methods in accordance with API Standard 1104. All welds that are defective welds, or have defects, shall be removed and that section of joint shall then be re-welded. After the repair is made, the joint shall be checked by repeating the original test procedure, at no expense to the Owner.
   2. Fillet welds shall be tested by the CONTRACTOR per Magnetic Particle Inspection ASME Section VIII, Div. 1, Appendix VI, or liquid dye penetrant per ASTM E165 - Method A. Defects shall be removed, re-welded, and retested.
   3. Repair of Welds: All welds that are defective shall be repaired by the Contractor to meet the requirements of the applicable sections of these specifications. Defects in welds or defective welds shall be removed, and that section of the joint shall then be re-welded. Only sufficient removal of defective material that is necessary to correct the defect is required. After the repair is made, the joint shall be checked by repeating the original test procedure. Welds deficient in size shall be repaired by adding weld metal.

E. Following tests of the joint, coat the exterior joint spaces as indicated. Holiday test tape wrapped pipe, including heat shrink sleeves, as approved by the Engineer. After a successful Holiday test, backfilling may be completed.

F. Lining and Coating of Field Joints:

   1. General: The interior and exterior joint recesses shall be thoroughly wiped clean and all water, loose scale, dirt and other foreign material shall be removed from the inside surface of the pipe. The cement for joint grout shall be Type II as specified in MAG Section 725.
   2. Cement-mortar Joint Lining: After the backfill has been completed to final grade, the interior joint recess shall be filled with mortar of stiff consistency. The mortar shall be tightly packed into the joint recess and troweled flush with the interior surface, and all excess shall be removed. At no point shall there be an indentation or projection of the mortar exceeding 1/16-inch. With pipe smaller than 24 inches in diameter, before the spigot is inserted into the bell, the bell shall be daubed with mortar. The spigot end then shall be forced to the bottom of the bell and excess mortar on the inside of the joint shall be swabbed out.
   3. Liquid Epoxy or Polyurethane Joint Lining: Use the primary lining material that has been used on the shop lined pipe sections as recommended by the manufacturer. Remove water, mud, dirt, grease, weld splatter and any deleterious matter form the area to be coated. Clean steel surface to a SSPC-SP10 finish with a profile as recommended

by the manufacturer. Avoid moisture contamination by maintaining the substrate surface temperature 5 degrees F above the dew point. Apply lining to the same thickness as the shop-applied lining.

4. Joint Coating: In accordance with coating system provided for adjacent main line pipe.
   a. Section 09810, Pipeline Tape Coating.
   b. Section 09910, Polyurethane Coating.

G. Flanged Joints:

1. Before the joint is assembled, the flange faces shall be thoroughly cleaned of all foreign material with a power wire brush. The gasket shall be centered and the connecting flanges drawn up watertight without unnecessarily stressing the flanges.
2. All bolts shall be tightened in a progressive diametrically opposite sequence and torqued with a suitable, approved and calibrated torque wrench. Torque values shall be as recommended by the pipe manufacturer. All clamping torque shall be applied to the nuts only.
3. All buried flanges shall be coated and protected with tape or heat-shrinkable sleeves in accordance with Section 09810, Pipeline Tape Coating.

H. Mechanical Couplings (AWWA C219) (Restrained Dismantling Joints):
1. When installing couplings, care shall be taken that the connecting pipe ends, couplings and gaskets are clean and free of all dirt and foreign matter with special attention being given to the contact surfaces of the pipe, gaskets and couplings. Install in conformity with the recommendation and instruction of the coupling manufacturer.
2. Wrenches used in bolting couplings shall be of a type and size recommended by the coupling manufacturer. Tighten coupling bolts so as to secure a uniform annular space between the follower rings and the body of the pipe with bolts tightened approximately the same amount. Tighten diametrically opposite bolts progressively and evenly. For final tightening, use a suitable, approved and calibrated torque wrench set for the torque recommended by the coupling manufacturer. Apply clamping torque to the nut only.
3. Upon completion of the coupled joint, the coupling and bare metal of the pipe shall be cleaned, primed and protected with heat shrinkable sleeve in accordance with the requirements of Section 09810, Pipeline Tape Coating.

I. Insulated Joints: Insulated joints and appurtenant features shall be made by the Contractor as shown. Exercise special care to prevent electrical conductivity across the joint. Conduct an electrical resistance test after the insulated joint is completed. Should the resistance test indicate a short circuit, the Contractor shall remove the insulating units to inspect for damages, replace all damaged portions, and reassemble the insulating joint. The insulated joint shall then be retested to assure proper insulation.

3.04 FIELD-APPLIED CEMENT-MORTAR LINING

A. Except as otherwise indicated, lining of steel pipe shall be in accordance with AWWA C602.

B. After joints are welded, air tested, and coated, and bedding and backfill have been placed, begin cleaning and lining operation with approval of Engineer.

C. Install wire mesh reinforcement in the lining of specials in accordance with AWWA C205.

D. Maintain lining and keep lining moist until final acceptance.

3.05 REPAIR OF SHOP-APPLIED COATINGS

A. Coatings: In accordance with coating system provided for adjacent main line pipe.
   1. Section 09810, Pipeline Tape Coating.
   2. Section 09910, Polyurethane Coating.

B. All Other Coatings: In accordance with Section 09900, Painting.

3.06 INSTALLATION OF PIPE APPURTENANCES

A. Protection of Appurtenances: Where the joining pipe is tape-coated, buried appurtenances shall be coated with cold-applied tape in accordance with ANSI/AWWA C209, Type II.

B. Installation of Valves: All valves shall be handled in a manner to prevent any injury or damage to any part of the valve. All joints shall be thoroughly cleaned and prepared prior to installation. The Contractor shall adjust all stem packing and operate each valve prior to installation to insure proper operation.

C. All buried valves shall be coated and protected in accordance with Section 09900 - Painting

D. All valves shall be installed so that the valve stems are plumb and in the location shown.

E. Test Station/Pipeline Markers: Install at all test stations, manways, bends, air release valves, isolation valves, and blowoff locations.

3.07 PRESSURE AND LEAKAGE TESTING

A. General:
   1. Test piping after installation in accordance with MAG Standard Specification 610 and Section 610.14 of the City of Phoenix Supplements to the Uniform MAG Standard Specifications and as specified herein.
   2. Test piping with water. Contractor shall furnish all labor and material, and all water required for pressure testing and obtain all permits for test water discharge at no additional cost to the Owner. All test water shall be potable. No other water shall be allowed in the pipe.
   3. All pressure pipelines shall be tested. All testing operations shall be performed in the presence of the Owner.

4. Prior to hydrostatic testing, all pipelines shall be thoroughly cleaned and flushed or blown out as appropriate. The Contractor shall test all pipelines either in sections or as a unit. No section of the pipeline shall be tested until all field-placed concrete or mortar has attained a strength of 3000 psi.
5. The test shall be made by closing valves or by placing temporary bulkheads in the pipe and filling the line slowly with water. The Contractor shall be responsible for ascertaining that all test bulkheads are suitably restrained to resist the thrust of the test pressure without damage to, or movement of, the adjacent pipe. Any unharnessed sleeve-type couplings, expansion joints, or other sliding joints shall be restrained or suitably anchored prior to the test, to avoid movement and damage to piping and equipment.
6. The Contractor shall provide sufficient temporary air tappings in the pipelines to allow for evacuation of all entrapped air in each pipe segment to be tested. After completion of the tests, such taps shall be permanently plugged. Care shall be taken to see that all air vents are open during filling.
7. The pipeline shall be filled at a rate which will not cause any surges or exceed the rate at which the air can be released through the air valves at a reasonable velocity and all the air within the pipeline shall be properly purged.

B. Pressure Test Requirements:
1. Test pressure shall be 188 psi.
2. Duration of pressure test: 2 hours.
3. The pressure test shall begin after the pipe has been filled with water and allowed to stand under a slight pressure for a minimum of 48 hours to allow the concrete or mortar lining, as applicable, to absorb what water it will and to allow the escape of air from any air pockets. During this period, bulkheads, valves, and connections shall be examined for leaks. If leaks are found, corrective measures satisfactory to the Engineer shall be taken.
4. Maximum length of pipe to be tested in a single pressure test is 2.5 miles.
5. All visible leaks shall be repaired in a manner acceptable to the Owner.

C. Leakage Test:
1. Leakage test shall be made after pressure test has been completed.
2. Leakage test shall comply with City of Phoenix supplement to MAG except as modified herein.
3. The maximum allowable leakage for transmission pipelines shall be determined as follows:

$$L = \frac{ND(P)^{\frac{1}{2}}}{C}$$

Where:

L is the allowable leakage in gallons per hour.

N is the number of rubber-gasketed pipe joints in the test section.

D is the inside pipe test diameter in inches.

P is the pipe test pressure (psi), which is defined as the average of the highest and lowest test pressures in the pipe section being tested.

C is a constant as follows:
C = 7400

4. Pipe with welded joints shall have no leakage.
5. In the case of pipelines that fail to pass the prescribed leakage test, the Contractor shall determine the cause of the leakage, shall take corrective measures necessary to repair the leaks, and shall again test the pipelines. This shall continue until the pipeline passes the test.

3.08 DISINFECTION

A. Disinfect in accordance with City of Phoenix Supplements to Uniform MAG Standard Specification 611.15, MAG Standard Specification Section 611 and AWWA C651. Contractor shall disinfect by means of slug method of disinfection, except that if Contractor can demonstrate viability of the continuous feed method, the Contractor may use this method at their discretion.

3.09 DISPOSAL OF TEST WATER

A. General:
   1. At the conclusion of testing, Contractor shall dispose of test water in an approved manner. If hydrostatic testing is conducted independent of disinfection test, disposal must occur at the conclusion of each test. If hydrostatic and disinfection test are combined, disposal shall occur at end of combined test.
   2. Disposal can occur by the following methods:
      a. Disposal into wash areas that traverse the pipe alignment.
   3. Contractor shall apply for and obtain any and all permits associated with disposal of test water.

B. Hydrostatic Test: If hydrostatic test is conducted independent of the disinfection test, Contractor must dispose of all test water immediately upon completion of the test.

C. Disinfection Test:

   1. At completion of disinfection test, dechlorinate and dispose of test water
   2. Contractor shall furnish all labor and material for dechlorination of disinfection water prior to discharge. Contractor shall obtain all permits for disinfection water discharge at no additional cost to Owner.

END OF SECTION

SECTION 15106

THERMOPLASTIC PIPE

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish and install and place in satisfactory service chlorinated polyvinyl chloride (CPVC) piping, fittings and specials.
   2. The extent of piping is shown on the Drawings and Section 15050, Piping Systems.

B. Coordination:
   1. Review installation procedures under other Sections and coordinate with the Work that is related to this Section.

1.2 QUALITY ASSURANCE

A. Manufacturer's Qualifications:
   1. Manufacturers of thermoplastic pipe and fittings shall have a minimum of five years of experience producing thermoplastic pipe and fittings, and shall be able to show evidence of at least five installations in satisfactory operation.

B. Reference Standards: Comply with applicable provisions and recommendations of the following, except as otherwise shown or specified.
   1. ASTM D1598, Test Method for Time-to-Failure of Plastic Pipe Under Constant Internal Pressure.
   2. ASTM D1599, Test Method for Short-Time Hydraulic Failure Pressure of Plastic Pipe, Tubing and Fittings.
   3. ASTM D1784, Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
   4. ASTM D2122, Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings.
   5. ASTM D2774, Practice for Underground Installation of Thermoplastic Pressure Piping.
   6. ASTM D2846, Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Hot- and Cold-Water Distribution Systems.
   7. ASTM D3034, Specification for Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
   8. ASTM F437, Specification for Threaded Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
   9. ASTM F439, Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.

10. ASTM F441, Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80.
11. ASTM F477, Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
12. ASTM F493, Specification for Solvent Cements for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe and Fittings.
13. Standard No. 14, National Sanitation Foundation.
14. American National Standards Institute.

C. Shop Tests:
1. Piping manufacturer shall maintain a continuous quality control program. All CPVC plastic molding materials used to manufacture pipe and fittings under this Section shall be tested for conformance to the requirements of ASTM D 1784.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
1. Detailed procedures to be used in jointing and installing piping system including manufacturer's recommendations.
2. Interfacing of piping system to equipment and appurtenances.
3. Detail requirements for burial, supports, anchors, guides, expansion joints, and all accessories required for a satisfactory piping system.
4. Bill of materials, indicating material composition of pipe, fittings and solvent, pressure rating, nominal size and its location on the piping installation drawings.
5. Certifications letter from pipe manufacturer confirming that the materials to be used are suitable for the intended service.

B. Certificates: Submit certificates of compliance with referenced standards.

1.4 PRODUCT DELIVERY, HANDLING AND STORAGE

A. Delivery: All necessary precautions shall be taken to prevent damage to pipe fittings and other materials during shipment and delivery. All materials shall be securely fastened to truck or rail car to prevent movement or damage during shipment. All materials shall be inspected by CONTRACTOR, upon delivery to the site.

B. Handling: All pipe materials shall be handled to prevent damage. Pipe and fittings shall not be dropped, rolled, or pushed off from any height on delivery, storage or installation.

C. Storage: All pipe materials shall be stored off the ground. Pipe ends shall be secured by caps or plugs. Do not store pipe or fittings in sunlight. Pipe shall be stored to prevent sagging or bending. Store off the ground, under cover, and in a dry location.

PART 2 - PRODUCTS

2.1 MATERIALS

A. CPVC Pipe:
   1. CPVC pipe shall be Schedule 80, Class 23447-B, conforming to ASTM D 1784 and ASTM F 441.
   2. Fittings shall be Schedule 80, solvent welded, socket type, conforming to ASTM F 439. Solvent cement shall conform to requirements of ASTM F 493.
   3. Provide flanged fittings at all valves and equipment with EPDM gaskets, unless shown otherwise on the Drawings. Provide Type 316 stainless steel bolts and nuts.

B. PVC Gravity Sewer Pipe:
   1. Pipe and fittings shall conform to requirements of ASTM D1784, Class 12454-B and ASTM D 3034, SDR 26. Elastomeric gaskets for joints shall conform to requirements of ASTM F 477.

C. Couplings:
   1. Type: Quick-connect, male adapter with treaded ends for permanent pipe installation, hose shank coupler for hose connection.
   2. Materials:
      a. Body: Polypropylene.
      b. Cam Arms: Stainless steel.
      c. Gaskets: Viton or EPDM.
      d. Ends: As specified above.
   3. Each adapter provided shall be equipped with adapter cap constructed of same materials.
   4. Product and Manufacturer: Provide one of the following:
      a. Plastic Piping System, Inc.
      b. Or equal.
   5. Hose:
      a. Material of Construction: Cross-linked polyethylene tube, non-staining, with neoprene cover.
      b. Temperature Rating: Up to 150°F.
      c. Hose shall be high tensile, horizontal textile braid with helix wire reinforcements.
      d. Each hose shall be fitted with hose shank coupler.
      e. Product and Manufacturer: Provide one of the following:
         1) Goodyear Rubber Company.
         2) Or equal.

D. Expansion Joints (Bellows Type):
   1. Provide expansion joints as part of the pipe support system, as required.

2. Provide connections to storage tanks and scrubber vessels with expansion joints to compensate for expansion, contraction and misalignment. Connections requiring bellows type expansion joints are as follows:
   a. Pump suction lines.
   b. Fill pipes.
   c. Vent pipes.
   d. Recirculation pump suction lines.
   e. Recirculation pump discharge lines.
   f. Blowdown lines.
3. Features:
   a. Type: Flanged bellows type with three or five convolutions.
   b. Working Pressures (maximum):
      1) Three convolutions: 125 psi.
      2) Five convolutions: 50 psi.
   c. Materials of Construction:
      1) Bellows: TFE. Bellows material shall be wrapped around flanges for corrosion protection.
      2) Flanges: Cadmium plated steel.
   d. Reinforcing rings around bellows: Plated for corrosion protection.
   e. All expansion joints in gallery piping shall have limit rods for over expansion protection. Rods shall be sized with a safety factor of 1.5 above the maximum force developed.
4. Product and Manufacturers: Provide one of the following:
   a. Unaflex, Style 1000.
   b. Garlock, Style 200.
   c. Or equal.

E. Provide expansion compensation in accordance with the requirements of Section 15061, Pipe Hangers and Supports.

F. Supply type, grade and strength of pipe required to meet the specified service conditions. Submit to ENGINEER for approval.

G. Painting shall conform to requirements of Section 09900, Painting.

2.2 DETAILED REQUIREMENTS

A. Workmanship: The pipe shall be homogeneous throughout and free from visible cracks, holes, foreign inclusions or other defects. The pipe shall be uniform in color, opacity, density, and other physical properties.

B. Dimensions and Tolerances: Dimensions and tolerances shall be measured in accordance with ASTM D 2122. The eccentricity of the inside and outside circumferences of the pipe walls shall not exceed 12 percent.

C. Sustained Pressure: The pipe shall not fail, balloon, burst, or weep as defined in ASTM D 1598.

D. Burst Pressure: The minimum burst pressure shall be determined in accordance with ASTM D 1599.

E. Marking: Marking on the pipe shall include the following, spaced at intervals of not more than five feet.
   1. Pipe nominal size.
   2. Pipe schedule.
   3. Specification of plastic material.
   4. Type and grade of plastic.
   5. Date and place of manufacture.

F. Piping and fittings shall be manufactured with a minimum of two percent of titanium oxide for ultraviolet protection.

2.3 ADAPTERS

A. Where required to join piping of different materials, provide the required adapters, as recommended by the thermoplastic pipe manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General:
   1. Refer to Section 15050, Piping Systems, Section 15051, Buried Piping Installation, and Section 15052, Exposed Piping Installation, for piping installation, testing, cleaning and acceptance.
   2. Request instructions from ENGINEER before proceeding if there is a conflict between Contract Documents and manufacturer's recommendations.
   3. Pipe, fittings and accessories that are cracked, damaged, not identified or in poor condition will be rejected.

+ + END OF SECTION + +

SECTION 15112

ECCENTRIC PLUG VALVES, OPERATORS AND APPURTENANCES

PART I - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals required to furnish and install all eccentric plug valves, operators and appurtenances complete and operational as shown on the Drawings and as specified.
   2. The Work includes, but is not necessarily limited to, all valves required for buried, exposed, submerged and other types of piping, except where otherwise specifically included in other Sections.

B. Coordination:
   1. Review installation procedures under other Sections and coordinate with the Work which is related to this Section including buried piping installation, exposed piping installation and site utilities.

1.2 QUALITY ASSURANCE

A. Manufacturer's Qualifications:
   1. Manufacturer shall have a minimum of five years experience of producing substantially similar equipment, and shall be able to show evidence of at least five installations in satisfactory operation for at least five years.
   2. Each eccentric plug valve shall be the product of one manufacturer.

B. Unit Responsibility:
   1. Unit Responsibility shall assigned by CONTRACTOR as specified in Section 01600, General Equipment Provisions, to the individual gate suppliers for the entire gate assembly, including both the equipment provided under this A Certificate of Unit Responsibility shall be provided.

C. Reference Standards: Comply with applicable provisions and recommendations of the following, except as otherwise shown or specified.
   1. ANSI B16.1, Cast Iron Pipe Flanges and Flanged Fittings.
   2. ANSI B16.4, Cast Iron Fittings.
   3. ASTM A 48/A 48M, Specification for Gray Iron Castings.
   4. ASTM B 62, Specification for Composition Bronze or Ounce Metal Castings.
   5. ASTM A126, Specification for Gray Iron Castings for Valves, Flanges and Pipe Fittings.
   6. ASTM A307, Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.

7. ASTM A354, Specification for Quenched and Tempered Alloy Steel Bolts, Studs and Other Externally Threaded Fasteners.
8. ASTM A436, Specification for Austenitic Gray Iron Castings.
9. ASTM A536, Specification for Ductile Iron Castings.
10. ASTM A743/A743M, Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application.
11. ASTM A2472, Specification for Nickel-Copper Alloy Plate, Sheet and Strip.
12. ASTM B98/B98M, Specification for Copper-Silicon Alloy Rod, Bar and Shapes.
13. ASTM B127, Specification for Nickel-Copper Alloy Plate, Sheet and Strip.
14. AWWAC540, Power Actuating Devices for Valves and Sluice Gates.
15. AGMA Standards.
16. NEMA, National Electrical Manufacturer's Association.
17. National Electrical Code (NEC) current adoption.
18. City of Phoenix – Amendments to the National Electrical Code.

1.3 SUBMITTALS

A Certificate of Unit Responsibility attesting that CONTRACTOR has assigned, and the supplier accepts unit responsibility in accordance with the requirements of this Section and Section 01600, General Equipment Provisions. No other Submittal material will be reviewed until the certificate has been received and conforms to the specified requirements.

B. Shop Drawings: Submit for approval the following:
1. Comply with the requirements of Section 01332, Shop Drawing Procedures.
2. Manufacturer's literature, illustrations, paint certifications, specifications, detailed drawings, data and descriptive literature on all eccentric plug valves and appurtenances.
3. Deviations from Contract Documents
4. Engineering data including dimensions, materials, size and weight.
5. Fabrication, assembly and installation drawings.
6. Certificates of compliance with AWWA Standards, where applicable.
7. Corrosion resistance information to confirm suitability of the eccentric plug valve materials for the application. Information on chemical resistance of elastomers shall be furnished from the elastomer manufacturers.
8. Complete manufacturer’s nameplate data of eccentric plug valves.
9. Special tools list.
10. C_V values and headloss curves.
11. Calculations:
    a. Sizing of operating mechanism with extension stems.
    b. Sizing of gear actuators.
    c. Sizing of anchor bolts.

C. Operation and Maintenance Manuals:
   1. Submit complete installation, operation and maintenance manuals including test reports, maintenance data and schedules, description of operation and spare parts information.
   2. Furnish Operation and Maintenance Manuals in conformance with the requirements of Section 01781, Operation and Maintenance Data.

D. Shop Tests:
   1. Test motor operated eccentric plug valves before shipment to ensure that the mechanisms can close the valves in the specified time limit, and for proper seating.
   2. Hydrostatic tests shall be performed, when required by the valve specifications included herein.

E. Certificates: Where specified or otherwise required by ENGINEER, submit test certificates.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Deliver materials to the site to ensure uninterrupted progress of the Work.
   1. Deliver anchor bolts and anchorage devices, which are to be embedded in cast-in-place concrete, in ample time to not delay the Work.

B. Handle all eccentric plug valves and appurtenances very carefully. Eccentric plug valves which are cracked, dented or otherwise damaged or dropped will not be acceptable.

C. Store materials to permit easy access for inspection and identification. Keep steel members off the ground, using pallets, platforms or other supports. Protect steel members and packaged materials from corrosion and deterioration.

D. Store all mechanical equipment in covered storage off the ground and prevent condensation and in accordance with the manufacturer's recommendations for long term storage.

PART 2- PRODUCTS

2.1 MATERIALS

A. General:
   1. Eccentric plug valves shall have manufacturer's name and working pressure cast in raised letters on valve body.
   2. Manual eccentric plug valve operators shall turn clockwise to close, unless otherwise specified. Valves shall indicate the direction of operation.

3. Manually operated eccentric plug valves, with or without extension stems, shall require not more than a 40-pound pull on the manual operator to open or close a valve against the specified criteria. The gear actuator and the eccentric plug valve components shall be able to withstand a minimum pull of 200-pounds on the manual operator and an input torque of 300-foot pounds to an actuator nut. Manual operators include handwheel, chain, crank, lever and a T-handle wrench.
4. Unless otherwise specified, all flanged eccentric plug valves shall have ends conforming to ANSI B16.1. The pressure class of the flanges shall be equal to or greater than the specified pressure rating of the valves and piping.
5. Buried eccentric plug valves shall have flanged ends with mechanical joint adapters and installed with a flanged adapter or have grooved mechanical couplings. All bolts shall be Type 316 stainless steel.
6. Buried eccentric plug valves shall be provided with adjustable two piece valve boxes and provided with extension stems, operating nuts and covers, unless otherwise shown on the Drawings or specified. Extension stems shall terminate 12-inches below finished grade.
7. All bolts, nuts and studs on or required to connect buried, submerged valves or valves utilized for wastewater service shall be Type 316 stainless steel.
8. All bolts and studs embedded in concrete and studs required for wall pipe shall be of Type 316 stainless steel.
9. For stainless steel bolting, except where Nitronic-60 nuts are required, use anti-seize compound, graphite free, to prevent galling. Strength of the joint shall not be affected by the use of anti-seize compound.
10. All other bolts, nuts and studs shall, unless otherwise approved, conform to ASTM A307, Grade B; or ASTM A354.
11. Bolts and nuts shall have hexagon heads and nuts.
12. All materials of construction of the eccentric plug valves shall be suitable for the service identified in Section 15050, Piping Systems, and as shown on the Drawings.
13. Protect wetted parts from galvanic corrosion due to contact of two different metals.
14. Gasket material and installation shall conform to manufacturer's recommendations.
15. Identification: Identify each eccentric plug valve 4-inches and larger with a stainless steel manufacturer’s nameplate stamped with the approved designation. Manufacturer’s nameplate shall be permanently fastened to valve body at the factory. Stenciled designations are acceptable for buried valves.
16. Buried or submerged service eccentric plug valves shall be provided with greased filled actuators with position indicators.

B. Eccentric Plug Valves:
   1. General:
      a. Non-lubricated eccentric type plug valves shall be installed where flow through the valve will be in only one direction.

b. Eccentric plug valve shall have flanged ends. Flanges shall be faced and drilled to ANSI B16.l, Class 300.

2. Eccentric Plug Valves:
   a. Valves shall have a valve port area of a minimum 80 percent of the full pipe area. Special application eccentric plug valves shall be provided with a port area of 100 percent of full pipe area as shown on the Drawings.
   b. Valves shall be rated for a minimum working pressure of 300 psig.
   c. Exposed valve flanges shall be faced and drilled in accordance with ANSI B16.1, Class 300. Buried valves shall be provided with flange ends with mechanical joint adapters.
   d. Valve bodies shall be ASTM A126 Class B cast iron.
   e. Valves shall be furnished with replaceable stainless steel sleeve-type bearings in the upper and lower journals. These bearings shall comply with the applicable sections of AWWA C507 and AWWA C504. Bearings shall be of sintered, oil impregnated permanently lubricated Type 316 stainless steel for valves 12-inch and smaller. Bearings shall be ASTM A 743/A 743M Grade CF-8M, ANSI Type 316 stainless steel for Teflon coated Type 316 stainless steel for valves 14-inches and larger.
   f. Shaft seals shall be of the multiple V-ring type, externally adjustable, replaceable without removing the bonnet or actuator from the valve, repackable under pressure and shall comply with the applicable sections of AWWA C504 and AWWA C507. Packing shall be adjustable acrylonitrile-butadiene reinforced filler for aboveground valves.
   g. Eccentric plug valves for liquid service shall have a balanced plug coated with a vulcanized resilient isobutene-isoprene solidly bonded to a semi-steel core, as required, to assure low torque and drip-tight shutoff, suitable for bi-directional shutoff, with sewage, grit, sludge, potable and non-potable water operating at a temperature of 250°F.
   h. Products and Manufacturers: Provide one of the following:
      1) DeZurik Corporation.
      2) Val-Matic Valve & Mfg. Corp.

3. All Eccentric Plug Valves:
   a. All valves 6-inches in diameter and larger and all manually operated eccentric plug valves installed more than five feet above the operating floor regardless of size, shall be equipped with a geared operator.
   b. Manually operated valves smaller than 6-inches diameter installed five feet or less above the operating floor shall be lever wrench operated.
   c. Size gear actuators for valves 8-inch and smaller for 175 psig differential pressure.
   d. Size gear actuators for valves larger than 6-inch for the following maximum differential pressures:
      1) Valve Size and Location: as indicated on the Drawings.
      2) Maximum Differential Pressure Across Closed Valve: 300 psig.
   e. Design the actuators to hold the valves in any intermediate position without creeping or vibrating.

f. Provide a valve position indicator on each actuator. Provide stop-limiting devices for open and closed position.
g. Provide an adjustable stop to adjust the seating pressure.
h. Make packing accessible for adjustment without requiring the removal of actuator from the valve.
i. The diameter ratio of the handwheel or the chainwheel and the gear sector shall be less than two.
j. For buried or submerged valves, the gear actuator shall be grease-packed and designed to withstand submersion and be driptight in water to 20 feet submergence.
k. Provide each actuator with gearing totally enclosed.
l. The operator shaft and the gear sector shall be supported on permanently lubricated bronze bearings.
m. Provide metal encased spring loaded seals in top and bottom covers of the gear housing.
n. Actuators shall be designed to produce the indicated torque with a maximum pull of 40-pounds on the handwheel or chainwheel and a maximum input of 150-foot pounds on operating nuts, both for seating and unseating heads equal to the maximum differential pressure.
o. All actuator components between the input and the stops shall be designed to withstand, without damage, a pull of 200-pound for handwheel or chainwheel actuators and an input torque of 300-foot pound for operating nuts when operating against the stops.
p. Materials of Construction:
    1) Housing: ASTM A126 Class B cast iron.
    2) Gear Sector: Ductile Iron ASTM A536 or
    Cast Iron ASTM A126 Class B.
    3) Worm Gear: Steel, AISI 1144, hardened and tempered to an average Rc 40 and within range of Rc 35 to 45.
    4) All Bearings: Bronze oil impregnated.
    5) All Hardware including Bolts, Nuts, Washers, Set Screws and Pins: Type 316 stainless steel.
q. Valves higher than five feet above the operating floor:
    1) Chainwheels, sprockets and Type 316 stainless steel chain shall be provided for gear operated valves mounted more than five feet above the operating floor.
    2) Chain shall extend to three feet above the operating floor.
    3) Gearing shall be enclosed in a semi-steel housing and shall be suitable for running in a lubricant, with seals provided on all shafts to prevent entry of dirt and water into the operator.
    4) Operator shaft and the gear quadrant shall be supported on permanently lubricated stainless steel bearings.
    5) Operator shall clearly indicate valve position and an adjustable stop shall be provided to set closing torque.
    6) Exposed nuts, bolts and washers shall be Type 316 stainless steel.

r. Where lever wrench operated valves are required, each valve shall be furnished with its own lever wrench operator.

s. Extension Bonnets: Where required, extension bonnets shall be provided. Extension bonnet shall be of Type 316 stainless steel, with Type 316 stainless steel stems, constructed so that when connected to the valve the extension bonnet shall be vertical, and designed to fully support the operator and stem extension. Exposed extension stems shall be of Type 316 stainless steel. Intermediate bearings shall be provided on the extension bonnet, as required.

t. Valve packing adjustment on non-submerged valves shall be accessible without removing the actuator from the valve.

u. Shop Painting:

1) Interior ferrous metal surfaces of the valve except finished or bearing surfaces and the plug, shall be shop painted with two coats of an approved two component coal tar epoxy coating applied in accordance with the manufacturer's recommendations.

2) Exterior surfaces of the valve and operator shall be shop painted as specified hereinafter under Article 2.8, below.

4. Eccentric Plug Valves - Guarantee:

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ECCENTRIC PLUG VALVES - GUARANTEE

WHEREAS

of (Address)
, Telephone:

Herein called the "Valve Manufacturer" has furnished eccentric plug valves on the following Project:

City of Phoenix
Water Services Department
Lift Station 66 Refurbishment

OWNER: City of Phoenix

Guarantee Period: Five years Date of Final Acceptance:
Date of Expiration:

AND WHEREAS the Valve Manufacturer has contracted (either directly with the OWNER or indirectly as a subcontractor) to Guarantee said Valves against leaks and faulty or defective materials and workmanship for the designated Guarantee Period;

NOW THEREFORE the Valve Manufacturer hereby Guarantees, subject to the terms and conditions herein set forth, that during the Guarantee Period he will at his own cost and expense, make or cause to be made such repairs to or replacements of said Valves as are necessary to correct faulty and defective work, and as are necessary to maintain said Valves to operate as specified.

This Guarantee is made subject to the following terms and conditions:

1. Specifically excluded from this Guarantee are damages to the Valves caused by: a) lightning, and other unusual phenomena of the elements; b) fire. When the Valves have been damaged by any of the foregoing causes, the Guarantee shall be null and void until such damage has been repaired by the Valve Manufacturer, and until the cost and expense thereof has been paid by the OWNER or by another responsible party so designated.
2. During the Guarantee Period if the OWNER allows alteration of the Valves by anyone other than the Valve Manufacturer, including maintenance in connection with other Work, this Guarantee shall become null and void upon the date of said alterations. If the OWNER engages CONTRACTOR to perform said alterations, the Guarantee shall not become null and void, unless the Valve Manufacturer, prior to proceeding with said Work shall have notified the OWNER, in writing, showing reasonable cause for claim that said alterations

would likely damage or deteriorate the Valves, thereby reasonably justifying a termination of this Guarantee.

3. The OWNER shall promptly notify the Valve Manufacturer of observed known or suspected, defects or deterioration, and shall afford reasonable opportunity for the Valve Manufacturer to inspect the valves, and to examine the evidence of such leaks, defects or deterioration.
4. This Guarantee is recognized to be the only Guarantee of the Valve Manufacturer on said Valves, and shall not operate to restrict or cut off the OWNER from other remedies and recourses lawfully available to him in cases of valves failures. Specifically, this Guarantee shall not operate to relieve the Valve Manufacturer of his responsibility for performance of the Valves, regardless of whether original contract was a contract directly with the OWNER or a subcontract with the OWNER'S CONTRACTOR.

IN WITNESS THEREOF, this instrument has been duly executed this _____ day of _____, 20__.

Valve Manufacturer's Signature:

Typed Name:

As Its (position):

And has been countersigned by CONTRACTOR issuing the Valve Manufacturer's subcontract for said Valves:

Name of CONTRACTOR:

Date: Authorized Signature:

Typed Name:

As Its (position):

(The remainder of this page was left blank intentionally.)

2.2 APPURTENANCES FOR EXPOSED VALVES

A. General:
   1. For valves located less than 5 feet-0 inches above the operating floor, provide levers on 4-inch quarter turn valves and handwheels on all other valves, unless otherwise shown on the Drawings or specified.
   2. For valves located at 5 feet-0 inches or more above the operating floor, provide chain operators.
   3. Where shown on the Drawings, provide extension stems and floorstands.

B. Handwheels:
   1. Conform to the applicable AWWA Standards.
   2. Material of Construction: Type 316 stainless steel.
   3. Arrow indicating direction of opening and word "OPEN" shall be cast on the trim of the handwheel.
   4. Maximum Handwheel Diameter: 30-inches.

C. Chain Operators:
   1. For valves more than 5 feet-0 inches above the operating floor provide chain operators.
   2. Chains shall extend to three feet above the operating floor.
   3. A 1/2-inch stainless steel hook bolt shall be provided to keep the chain out of the walking area.
   4. Materials of Construction:
      a. Chain: Type 316 stainless steel.
      b. Chain wheel: Recessed groove type made out of bronze bushed with guides.
   5. Chain Construction:
      a. Chain shall be of welded link type with smooth finish. Chain that is crimped or has links with exposed ends shall not be acceptable.
   6. Provide geared operators where required to position chain wheels in vertical position.

D. Crank Operator:
   1. Crank operator shall be removable and fitted with a rotating handle.
   2. Maximum Radius of Crank: 15-inches.
   3. Materials:
      a. Crank: Type 316 stainless steel.
      b. Handle: Type 316 stainless steel.
      c. Hardware: Type 316 stainless steel.

E. Extension Stems and Floorstands for Valves:
   1. Conform to the applicable requirements of AWWA C501 for sizing of the complete lifting mechanism.
   2. Bench and Pedestal Floorstands:

a. For valves requiring extension stems, provide bench or pedestal floorstands with handwheel or crank as indicated. Make provisions for use of portable electric actuator for opening and closing of the valves.
b. Type: Heavy-duty with tapered roller bearings enclosed in a weatherproof housing, provided with positive mechanical seals around lift nut and pinion shaft to prevent loss of lubrication and to prevent moisture from entering the housing. A lubrication fitting shall be provided for grease. The base shall be machined.
c. Materials of Construction:
   1) Housing: Type 316 stainless steel.
   2) Lift Nut: Type 316 stainless steel.
   3) Grease Fitting: Type 316 stainless steel.
   4) All Bolting: Type 316 stainless steel.

3. Wall brackets for floorstands shall be of Type 316L stainless steel construction.
4. Extension Stems:
   a. Materials of Stems and Stem Couplings: Type 316 stainless steel.
   b. Maximum Slenderness Ratio (L/R): 100.
   c. Minimum Diameter: 1.5-inch.
   d. Threads: ACME.
   e. Stem couplings shall be provided where stems are furnished in more than one piece. The couplings shall be threaded and keyed or threaded and bolted and shall be of greater strength than the stem.
   f. A Type 316 stainless steel cap suitable for the square end of the valve stem shall be welded to the bottom of the extension stem.
5. Bottom Couplings: Ductile iron with Type 316 stainless steel pin and set screw.
6. Stem Guides:
   a. Material: Type 316 cast stainless steel with bronze bushing for stem.
   b. Maximum Stem Length between Guides: Seven feet.
   c. Stem guides shall be adjustable in two directions.

F. Floor Boxes: Provide cast-iron floor boxes for all valves which are to be operated from floor above valve. Boxes shall be equal in depth to floor slab. Boxes shall have cast-iron covers and be fitted with bronze bushing.

2.3 APPURTENANCES FOR BURIED VALVES

A. Wrench Nuts:
1. Provide wrench nuts on all buried valves of nominal 2-inch size conforming to AWWA C500.
2. Arrow indicating direction of opening the valve shall be cast on the nut along with the word "OPEN".
3. Material: Ductile iron.
4. The nut shall be secured to the stem by mechanical means.

B. Extension Stems for Non-Rising Stem Valves and Quarter Turn Buried Valves:

1. Provide extension stems to bring the operating nut to 12-inches below the valve box cover.
2. Minimum Size and Material: Same as valve stem.
3. Maximum Unsupported Length: Three feet.
4. Provide top nut and bottom coupling of ductile iron with pins and set screws of Type 316 stainless steel.

C. Valve Boxes:
1. Valve boxes shall be as shown on the Drawings and as required.
2. Type: Heavy-duty, suitable for highway loading, two piece telescopic, and adjustable. Lower section shall enclose operating nut and stuffing box and rest on bonnet.
3. Material: Cast or ductile iron.
4. Coating: Two coats of asphalt varnish conforming to Federal Specification TT-C-494.
5. Marking: As required for service.

2.4 ANCHOR AND MISCELLANEOUS MOUNTING BOLTS

A. All bolts, nuts and washers for connection of the valve appurtenances to concrete structure or other structural members shall be obtained from the valve manufacturer, and shall be of ample size and strength for the purpose intended. Anchor bolts shall be hooked or adhesive type and shall be Type 316 stainless steel, except submerged which shall be Type 2205 duplex stainless steel. Anchor bolts shall conform to the requirements of Section 05051, Anchor Bolts, Toggle Bolts and Concrete Inserts.

B. Provide anchor bolts for stem guides of required strength to prevent twisting or sagging of the guides under load.

C. Provide bolts, nuts and washers of Type 316 stainless steel. The bolts shall have rolled threads and both bolts and nuts shall be electropolished to remove burrs.

D. Minimum Size of Anchor Bolts: 5/8-inch.

2.6 TOOLS AND SPARE PARTS

A. Provide the following T-Handle Operating Wrenches for Buried Valves:
1. Length of T-Handle Operating Wrench: 5-ft unless indicated otherwise.
2. Quantity: 2.

2.7 PAINTING

A. Clean and shop prime coat and shop finish coat ferrous metal surfaces of equipment in accordance with the requirements of Section 09900, Painting.

B. Coat machined, polished and non-ferrous surfaces including gears, bearing surfaces and similar unpainted surfaces with corrosion prevention compound which shall be maintained during storage and until equipment begins operation.

C. Field painting shall conform to the requirements under Section 09900, Painting.

D. Certify, in writing, that the shop primer and coating system is compatible with the finish coating system in accordance with Section 09900, Painting.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install all valves and appurtenances in accordance with the manufacturer's instructions.

B. Conform to appendices of AWWA Standards, where applicable.

C. Install all valves so that operating handwheels or levers can be conveniently turned from operating floor without interfering with access to other valves and equipment, and as approved by the ENGINEER. Orient chain operators out of the way of the walking areas. Mount valves so that indicator arrows are visible from floor level.

D. Install all valves plumb and level. Install all valves to be free from distortion and strain caused by misaligned piping, equipment or other causes.

E. For buried valve installations, set valve boxes plumb and centered, with soil carefully tamped to a lateral distance of four feet on all sides of the box, or to the undisturbed trench face if less than four feet. Provide a flexible coupling next to a buried valve for ease of valve removal.

3.2 FIELD TESTS AND ADJUSTMENTS

A. Adjust all parts and components as required to provide correct operation of the valves.

B. Conduct a functional field test on each valve in the presence of the ENGINEER to demonstrate that each valve operates correctly.

C. Demonstrate satisfactory opening and closing of valves at the specified criteria requiring not more than 40-pounds effort on the manual actuators.

D. Test ten percent valves of each type by applying 200-pounds effort on the manual operators. There shall be no damage to the gear actuator or the valve.

3.3 MANUFACTURER'S SERVICES

A. A factory trained representative shall be provided for installation supervision, start-up and test services and operation and maintenance personnel training services. The representative shall make a minimum of 1 visits, minimum 2 hours on-site for each visit, to the site. The first visit shall be for assistance in the installation of equipment. The second visit shall be for checking the completed installation and start-up of the system. The third visit shall be as described under Section 01821, Instruction of Operations and Maintenance Personnel. Manufacturer's representative shall test operate the system in the presence of the ENGINEER and verify that the eccentric plug valves and appurtenances conform to the requirements. Representative shall revisit the job site as often as necessary until all trouble is corrected and the installation is entirely satisfactory.

B. All costs, including travel, lodging, meals and incidentals, shall be considered as included in CONTRACTOR'S bid price.

+ + END OF SECTION + +

SECTION 15113

THERMOPLASTIC VALVES, OPERATORS AND APPURTENANCES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals required to furnish and install all thermoplastic valves, operators and appurtenances complete and operational as shown on the Drawings and as specified.
   2. The Work includes, but is not necessarily limited to, all types of valves required for buried, exposed, submerged and other types of piping, except where otherwise specifically included in other Sections.

B. Coordination:
   1. Review installation procedures under other Sections and coordinate with the Work which is related to this Section including buried piping installation, exposed piping installation, site utilities, insulation, heating, ventilating and air conditioning and plumbing.

1.2 QUALITY ASSURANCE

A. Manufacturer's Qualifications:
   1. Manufacturer shall have a minimum of five years experience of producing substantially similar equipment, and shall be able to show evidence of at least five installations in satisfactory operation for at least five years.
   2. Each type of valve shall be the product of one manufacturer.

B. Unit Responsibility:
   1. Unit Responsibility shall assigned by the CONTRACTOR as specified in Section 01600, General Equipment Provisions, to the individual valve and gate suppliers for the entire valve or gate assembly, including both the equipment provided under this Section and the associated electric actuators provided under Section 11200, 480 Volt Motor-Operated Valve and Gate Actuators. A Certificate of Unit Responsibility shall be provided.

C. Reference Standards: Comply with applicable provisions and recommendations of the following, except as otherwise shown or specified.
   1. ANSI B16.1, Cast Iron Pipe Flanges and Flanged Fittings.
   2. ASTM A307, Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
   3. ASTM A354, Specification for Quenched and Tempered Alloy Steel Bolts, Studs and Other Externally Threaded Fasteners.

4. ASTM D1784, Specification for Rigid Poly (Vinyl Chloride) PVC Compounds and Chlorinated Poly (Vinyl Chloride) CPVC compounds.
5. ASTM F439, Specification for Socket-type, Chlorinated Poly (Vinyl Chloride)(CPVC) Plastic Pipe Fittings, Schedule 40.
6. ASTM F441, Specification for Chlorinated Poly (Vinyl Chloride)(CPVC) Plastic Pipe, Schedules 40 and 80.
7. ASTM F493, Specification for Solvent Cements for Chlorinated Poly (Vinyl Chloride)(CPVC) Plastic Pipe and Fittings.

1.3 SUBMITTALS

A All submittals are to comply with the requirements of Section 01320 1.4, Submittals.

B. Certificate of Unit Responsibility attesting that CONTRACTOR has assigned, and the supplier accepts unit responsibility in accordance with the requirements of this Section and Section 01600, General Equipment Provisions. No other Submittal material will be reviewed until the certificate has been received and conforms to the specified requirements.

C. Shop Drawings: Submit for approval the following:
1. Manufacturer's literature, illustrations, paint certifications, specifications, detailed drawings, data and descriptive literature on all valves and appurtenances.
2. Deviations from the Contract Documents.
3. Engineering data including dimensions, materials, size and weight.
4. Fabrication, assembly and installation drawings.
5. Certificates of compliance with AWWA Standards where applicable.
6. Corrosion resistance information to confirm suitability of the valve materials for the application. Information on chemical resistance of elastomers shall be furnished from the elastomer manufacturers.
7. Complete manufacturer's nameplate data of valves.
8. Special tools list.
9. C_v values and headloss curves.

D. Calculations:
1. Sizing of operating mechanism with extension stems.
2. Sizing of gear actuators.
3. Sizing of anchor bolts.

E. Operation and Maintenance Manuals:
1. Submit complete installation, operation and maintenance manuals including test reports, maintenance data and schedules, description of operation and spare parts information.
2. Furnish Operation and Maintenance Manuals in conformance with the requirements of Section 01781, Operation and Maintenance Data.

F. Shop Tests:
   1. Test motor operated valves before shipment to ensure that the mechanisms can close the valves in the specified time limit, and for proper seating.
   2. Hydrostatic tests shall be performed, when required by the valve specifications included herein.

G. Certificates: Where specified or otherwise required by ENGINEER, submit test certificates.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Deliver materials to the site to ensure uninterrupted progress of the Work. Deliver anchor bolts and anchorage devices which are to be embedded in cast-in-place concrete in ample time to prevent delay of the Work.

B. All boxes, crates and packages shall be inspected by CONTRACTOR upon delivery to the site. Notify ENGINEER of any loss or damage exists to equipment or components. Replace lost equipment or components and repair damage to new condition in accordance with manufacturer's instructions.

C. Store materials to permit easy access for inspection and identification. Keep all materials off ground, using pallets, platforms or other supports. Protect steel members and packaged materials from corrosion and deterioration.

D. Store all mechanical equipment in covered storage off the ground and prevent condensation and in accordance with the manufacturer's recommendations for long term storage.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General:
   1. Valves shall have manufacturer's name and working pressure cast in raised letters on valve body.
   2. Manual valve operators shall turn clockwise to close, unless otherwise specified. Valves shall indicate the direction of operation.
   3. Unless otherwise specified, all flanged valves shall have ends conforming to ANSI B16.1, Class 125.
   4. Buried valves shall have flanged ends with mechanical joint adapters and installed with a flanged adapter or have grooved mechanical couplings. All bolts shall be Type 316 stainless steel.
   5. Buried valves shall be provided with adjustable two piece valve boxes and provided with extension stems, operating nuts and covers unless otherwise

shown or specified. Extension stems shall terminate 12-inches below finished grade.

6. All bolts, nuts and studs on or required to connect buried or submerged valves shall be Type 316 stainless steel.
7. All bolts and studs embedded in concrete and studs required for wall pipe shall be of Type 316 stainless steel.
8. For stainless steel bolting, except where Nitronic-60 nuts are required, use anti-seize compound, graphite free, to prevent galling. Strength of the joint shall not be affected by the use of anti-seize compound.
9. All other bolts, nuts and studs shall, unless otherwise approved, conform to ASTM A 307, Grade B or ASTM A 354.
10. Bolts and nuts shall have hexagon heads and nuts.
11. Gasket material and installation shall conform to manufacturer's recommendations.
12. Identification: Identify each valve 4-inches and larger with a stainless steel manufacturer's nameplate stamped with the approved designation. Manufacturer's nameplate shall be permanently fastened to valve body at the factory. Stenciled designations are acceptable for buried valves.
13. All materials of construction of the valves shall be suitable for the applications as shown on the Drawings.
14. Responsibility to coordinate compatible materials of construction for all wettable parts of all valves for each process application belongs to CONTRACTOR. Acceptable compatible materials of construction for wettable materials are as follows:

Process Fluid	**Compatible Materials of Construction**
Ferric Chloride	CPVC, Buna, EPDM, Teflon, Viton
Hydrochloric Acid	PVDF, Teflon, Viton
Sodium Hydroxide	CPVC, Teflon, Hypalon, Polypropylene, EPDM
Sodium Hypochlorite	CPVC, Teflon, PVDF, Hypalon, Polypropylene
Polymer	CPVC, Viton, Teflon
Methanol	HDPE, Buna-N, Teflon

B. CPVC Check Valves:

1. Check valves on CPVC piping shall be manufactured of chlorinated polyvinyl chloride (CPVC) material with seats and seals which are compatible with the process fluid.
2. CPVC shall be Type 4, Grade 1, in accordance with the requirements of ASTM D 1784.
3. Valves shall be true union type or flanged, rated for 100 psi service minimum, and shall be suitable for installation in either the horizontal or vertical plane.
4. Limit switches shall be provided for check valves as shown on the Drawings.

a. The valve shall be provided with two SPDT limit switches for remote position indication.
b. Limit Switch Rating: 15 amps, 120 VAC.
c. Limit switches shall be provided in a NEMA 4X enclosure.

5. Product and Manufacturer: Provide one of the following:
a. Nibco Incorporated.
b. Hayward Manufacturing Company.
c. ASAHI/America
d. Spears
e. Or equal.

C. Butterfly Valves - Non-Metallic:
1. Valve body shall be constructed of chlorinated polyvinyl chloride (CPVC) and shall be of the flange type suitable for mounting between mating flanges with ANSI B16.1, Class 125 drilling. CPVC shall not be subject to crazing, cold flow, aging, work hardening, or deterioration, and suitable for the design conditions.
2. Disc shall be of polypropylene construction. Shaft shall be of Type 316 stainless steel. Bushings shall be TFE surfaced requiring no lubrication. Disc seals shall be provided for positive sealing.
3. Manual operators shall be a locking handle constructed of reinforced plastic.
4. Limit Switches:
a. The valves shall be provided with precision snap action limit switches as shown on the Drawings.
b. Limit switch rating: SPDT 15 amps, 120 VAC enclosed in a NEMA 4X enclosure.
5. Product and Manufacturer: Provide one of the following:
a. ASAHI/America.
b. George Fisher.
c. Or equal.

D. CPVC Ball Valves:
1. Ball valves on CPVC piping shall be manufactured of chlorinated polyvinyl chloride (CPVC) material with seats and seals which are compatible with the process fluid.
2. CPVC shall be Type 4, Grade 1, in accordance with the requirements of ASTM D 1784.
3. Valves shall be true union type and rated for 150 psi service.
4. Limit Switches shall be provided for ball valves as shown on the Drawings.
a. The valves shall be provided with two SPDT limit switches for remote position indication.
b. Limit switch rating: 15 amps, 120 VAC.
c. Limit switches shall be provided in a NEMA 4X enclosure.
5. Product and Manufacturer: Provide one of the following:
a. Nibco Incorporated.

b. Hayward Manufacturing Company.
c. ASAHI/America
d. Spears
e. Or equal.

E. Diaphragm Valves:
1. Diaphragm valves shall be of CPVC body construction with rising stem and travel stop suitable for 100 psi working pressure at 120°F.
2. Diaphragm shall be EPDM, PVDF material compatible with the liquid, pressure and service.
3. Valves shall be true union type and be rated for 150 psi service.
4. Valves shall be furnished with manual handwheel operator and indicator. Provide chain wheel operator where valves are located 5 feet-0 inches or higher above the floor.
5. Limit Switches shall be provided for diaphragm valves as shown on the Drawings.
   a. The valves shall be provided with two SPDT limit switches for remote position indication.
   b. Limit switch rating: 15 amps, 120 VAC.
   c. Limit switches shall be provided in a NEMA 4X enclosure.
6. Product and Manufacturer: Provide one of the following:
   a. Hayward Plastics, Inc.
   b. ITT Fluid Technology Corporation.
   c. Or equal.

F. PVDF Ball Valves:
1. Ball valves on FRP piping shall be manufactured of PVDF material with Teflon seats and Viton seals.
2. Valves shall be true union flanged type and rated for 150 psi service.
3. Product and Manufacturer: Provide one of the following:
   a. Nibco Incorporated.
   b. Or equal.

G. PVDF Check Valves:
1. Check valves on FRP piping shall be manufactured of PVDF material with Teflon seats and seals.
2. Valves shall be flanged with ANSI B16.1, Class 125 drilling and shall be rated for 90 psi service.
3. Product and Manufacturer: Provide one of the following:
   a. ASAHI/America.
   b. Or equal.

H. CPVC Gate Valves:
   1. Gate valves on CPVC piping shall be manufactured of chlorinated polyvinyl chloride (CPVC) material with seats and seals which are compatible with the process fluid.
   2. CPVC shall be Type 4, Grade 1 in accordance with ASTM D 1784.
   3. Valves shall be flanged with tapered cylindrical plug design.
   4. Valves shall be provided with a position indicator and be of the non-rising stem design.
   5. Limit switches shall be provided for gate valves as shown on the Drawings.
      a. The valves shall be provided with two SPDT limit switches for remote position indication.
      b. Limit Switch Rating: 15 amps, 120 VAC.
      c. Limit switches shall be provided in a NEMA 4X enclosure.
   6. Product and Manufacturer: Provide one of the following:
      a. ASAHI/America.
      b. Or equal.

I. Basket Strainers:
   1. Basket Strainers - Simplex or Duplex as shown on the Drawings:
      a. End connections: 4-inches and larger, flanged; smaller than 4-inches, socket.
      b. Body: chlorinated polyvinyl chloride (CPVC) with one 3/8-inch NPT body drain.
      c. Screen:
         1) Chlorinated polyvinyl chloride (CPVC).
         2) Perforations: 1/16-inch.
         3) Open area not less than six times the corresponding cross-sectional pipe area.
      d. Strainer cover shall be removable without the use of tools.
      e. Product and Manufacturer: Provide one of the following:
         1) Hayward.
         2) Or equal.

2.2 ELECTRIC ACTUATORS

A. Electric actuators shall be furnished per the requirements of Section 11200, 480 Volt Motor-Operated Valve and Gate Actuators.

2.3 VALVE APPURTENANCES

A. Extension Stems, Stem Guides, Wrenches and Keys:
   1. Extension stem shall be at least as large as valve stem it operates.
   2. Provide intermediate stem guide for extensions more than seven feet long.

3. Stem brackets and guides shall be made of cast iron and have fully adjustable bronzed bushed guide block. Fasten brackets to walls with approved expansion bolts.
4. Operating nuts about 2-inches square shall be included with each extension stem and located in floor box or grating recess, as required.
5. Provide operating key or wrench of suitable length and size for each valve that is not readily accessible to direct operation.

B. Floor Boxes: Provide cast iron floor boxes for all valves, as shown on the Drawings, which are to be operated from floor above valve. Boxes shall be equal in depth to floor slab. Boxes shall have cast iron covers and shall be fitted with bronze bushing.

C. Handwheels:
1. Conform to the applicable AWWA Standards.
2. Material of Construction: Ductile iron or cast aluminum.
3. Arrow indicating direction of opening and word "OPEN" shall be cast on the trim of the handwheel.
4. Maximum Handwheel Diameter: 30-inches.

D. Chain Operators:
1. All valves more than 5 feet-0 inches above the operating floor level shall be equipped with chain operator and sprocket wheel bolted directly to the valve operating wheel.
2. Stainless steel chain shall be provided. Equip all operators with a 1/2-inch hook bolt located to keep chain out of walking areas.

E. Valve Boxes: Provide each buried valve with a valve box as follows:
1. Made of heavy pattern cast-iron, 2 piece adjustable telescoping type.
2. Lower section shall enclose operating nut and stuffing box and rest on bonnet.
3. Inside diameter shall be at least 4-1/2-inches.
4. Provide extension stem and operating nut.
5. Cover shall be heavy duty cast iron with direction to open arrow cast in.

2.4 SURFACE PREPARATION AND PAINTING

A. Valves, appurtenances, etc., shall receive shop primer and shop finish coating conforming to the requirements of Section 09900, Painting. If any damage to the paint system occurs, the equipment shall be repainted as directed by the ENGINEER.

B. Surface preparation and painting shall conform to the requirements of Section 09900, Painting.

C. All gears, bearing surfaces, machined surfaces and other surfaces which are to remain unpainted shall receive a heavy application of grease or other rust-resistant

coating. This coating shall be maintained during storage and until the equipment is placed into operation.

D. Certify, in writing, that the shop primer and shop finish coating system conforms to the requirements of Section 09900, Painting.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install all valves and appurtenances in accordance with the manufacturer's instructions.

B. Install all valves so that operating handwheels or levers can be conveniently turned from operating floor without interfering with access to other valves and equipment, and as approved by the ENGINEER. Orient chain operators out of the way of the walking areas. Mount valves so that indicator arrows are visible from floor level.

C. Install all valves plumb and level. Install all valves to be free from distortion and strain caused by misaligned piping, equipment or other causes.

D. For buried valve installations, set valve boxes plumb and centered, with soil carefully tamped to a lateral distance of four feet on all sides of the box, or to the undisturbed trench face if less than four feet.

3.2 FIELD TESTS AND ADJUSTMENTS

A. Adjust all parts and components as required to provide correct operation of the valves.

B. Conduct a functional field test on each valve in the presence of the ENGINEER to demonstrate that each valve operates correctly.

C. Demonstrate satisfactory opening and closing of valves at the specified criteria requiring not more than 40-pounds effort on the manual actuators.

D. Test ten percent valves of each type by applying 200-pounds effort on the manual operators. There shall be no damage to the gear actuator or the valve.

E. For motor operated valves, perform all field tests and adjustments required under Section 11200, 480 Volt Motor-Operated Valve and Gate Actuators.

3.3 MANUFACTURER'S SERVICES

A. A factory trained representative shall be provided for installation supervision, start-up and test services and operation and maintenance personnel training services. The representative shall make a minimum of 1 visits, minimum 2 hours on-site for each visit, to the site. The first visit shall be for assistance in the installation of equipment. The second visit shall be for checking the completed installation and start-up of the system. The third visit shall be as described under Section 01821, Instruction of Operations and Maintenance Personnel. Manufacturer's representative shall test operate the system in the presence of the ENGINEER and verify that the valves conform to requirements. Manufacturer's representative shall revisit the job site as often as necessary until all trouble is corrected and the installation is entirely satisfactory.

C. All costs, including travel, lodging, meals, and incidentals shall be considered as included in CONTRACTOR'S bid price.

+ + END OF SECTION + +

SECTION 15114

CHECK VALVES AND APPURTENANCES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals required to furnish and install all check valves and appurtenances complete and operational as shown on the Drawings and as specified.
   2. The Work includes, but is not necessarily limited to, all types of valves required for buried, exposed, submerged and other types of piping, except where otherwise specifically included in other Sections.

B. Coordination:
   1. Review installation procedures under other Sections and coordinate with the Work which is related to this Section including buried piping installation, exposed piping installation and site utilities.

1.2 QUALITY ASSURANCE

A. Manufacturer's Qualifications:
   1. Manufacturer shall have a minimum of five years experience of producing substantially similar equipment, and shall be able to show evidence of at least five installations in satisfactory operation for at least five years.
   2. Each type of check valve shall be the product of one manufacturer.

B. Reference Standards: Comply with applicable provisions and recommendations of the following, except as otherwise shown or specified.
   1. AGMA Standards.
   2. ANSI B16.1, Cast Iron Pipe Flanges and Flanged Fittings.
   3. ANSI B16.4, Cast Iron Fittings.
   4. ASTM A 48, Specification for Gray Iron Castings.
   5. ASTM A 126, Specification for Gray Iron Castings for Valves, Flanges and Pipe Fittings.
   6. ASTM A 216, Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service.
   7. ASTM A 240, Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels.
   8. ASTM A 285, Specification for Pressure Vessel Plates, Carbon Steel, Low-and Intermediate-Tensile Strength.
   9. ASTM A 307, Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.

10. ASTM A 354, Specification for Quenched and Tempered Alloy Steel Bolts, Studs and Other Externally Threaded Fasteners.
11. ASTM A 436, Specification for Austenitic Gray Iron Castings.
12. ASTM A 536, Specification for Ductile Iron Castings.
13. ASTM B 62, Specification for Composition Bronze or Ounce Metal Castings.
14. ASTM D 1784, Specification for Rigid Poly (Vinyl Chloride) PVC Compounds and Chlorinated Poly (Vinyl Chloride) CPVC compounds.
15. AWWA C111, Rubber-Gasket Joints for Ductile-Iron and Gray-Iron Pressure Pipe and Fittings.
16. AWWA C506, Backflow Prevention Devices - Reduced Pressure Principle and Double Check Valve Types.
17. AWWA C508, Swing Check Valves for Waterworks Service, 2-inch through 24-inch NPS.
18. NEMA, National Electrical Manufacturer's Association.
19. Comply with National Sanitation Foundation (NSF-61) and Arizona Administration Code requirements as stated in Specification Section 01420 – References.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Manufacturer's literature, illustrations, paint certifications, specifications, detailed drawings, data and descriptive literature on all valves and appurtenances.
   2. Deviations from Contract Documents.
   3. Engineering data including dimensions, materials, size and weight.
   4. Fabrication, assembly and installation drawings.
   5. Control characteristics of modulating valves.
   6. Certificates of compliance with AWWA Standards, where applicable.
   7. Corrosion resistance information to confirm suitability of the valve materials for the application. Information on chemical resistance of elastomers shall be furnished from the elastomer manufacturers.
   8. Power and control wiring diagrams, including terminals numbers.
   9. Complete manufacturer’s nameplate data of valves.
   10. Special tools list.
   11. Cv Values and headloss curves.

B. Operation and Maintenance Manuals:
   1. Submit complete installation, operation and maintenance manuals including test reports, maintenance data and schedules, description of operation, and spare parts information.
   2. Furnish Operation and Maintenance Manuals in conformance with the requirements of Section 01781, Operation and Maintenance Data.

C. Certificates: Where specified or otherwise required by ENGINEER, submit test certificates.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Deliver materials to the site to ensure uninterrupted progress of the Work. Deliver anchor bolts and anchorage devices, which are to be embedded in cast-in-place concrete, in ample time to not delay the Work.

B. All boxes, crates and packages shall be inspected by CONTRACTOR upon delivery to the site. Notify ENGINEER if any loss or damage exists to equipment or components. Replace loss and repair damage to new condition, in accordance with manufacturer's instructions.

C. Store materials to permit easy access for inspection and identification. Keep all material off the ground, using pallets, platforms or other supports. Protect steel members and packaged materials from corrosion and deterioration.

D. Store all mechanical equipment in covered storage off the ground and prevent condensation and in accordance with the manufacturer's recommendations for long term storage.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General:
1. Valves shall have manufacturer's name and working pressure cast in raised letters on valve body.
2. Unless otherwise specified, all flanged valves shall have ends conforming to ANSI B16.1. The pressure class of the flanges shall be equal to or greater than the specified pressure rating of the valves.
3. All bolts, nuts and studs on/or required to connect buried or submerged valves shall be Type 316 stainless steel.
4. All bolts and studs embedded in concrete and studs required for wall pipe shall be of Type 2205 duplex stainless steel.
5. For stainless steel bolting, except where Nitronic-60 nuts are required, use anti-seize compound, graphite free, to prevent galling. Strength of the joint shall not be affected by the use of anti-seize compound.
6. All other bolts, nuts and studs shall, unless otherwise approved, conform to ASTM A 307, Grade B; or ASTM A 354.
7. Bolts and nuts shall have hexagon heads and nuts.
8. Gasket material and installation shall conform to manufacturer's recommendations.

9. Identification: Identify each valve 4-inches and larger with a stainless steel manufacturer's nameplate stamped with the approved designation. Manufacturer's nameplate shall be permanently fastened to valve body at the factory. Stenciled designations are acceptable for buried valves.
10. All materials of construction of the valves shall be suitable for the applications as shown on the Drawings.
11. Protect wetted parts from galvanic corrosion due to contact of two different metals.

B. Check Valves - Liquid Service:
   1. General:
      a. Check valves shall absolutely prevent the return of water back through the valve when the upstream pressure decreases below the downstream pressure. The valve shall be tight seating.
   2. 2-1/2-Inches Diameter and Smaller: Valves shall be Type 316 stainless steel, screwed ends with screw in cap suitable for 125 psi service.
      a. As Manufactured by one of the following:
         1) Jenkins Brothers.
         2) Crane Company.
         3) Nibco.

C. 3-Inch Diameter and Larger – Non-Slam Swing Check Type:
   1. Provide valves conforming to AWWA C508-09 and as specified herein.
   2. Valve body shall be full flow equal to nominal pipe diameter at all points through the valve. The seating surface shall be on a 45 degree angle to minimize disc travel.
   3. The valve top access port shall be full size allowing removal of the disc without removing the valve from the line. The access cover shall be domed in shape to provide flushing action over the disc for operating in service containing solids. A threated port with pipe plug shall be provided in the access cover to allow for field installation of a mechanical, disc position indicator.
   4. The disc shall be of one-piece construction, precision molded with an integral O-ring type sealing surface. The flex portion of the disc contains nylon reinforcement and shall be warranted for 25 years. Non-Slam closing characteristics shall be provided through a short 35-degree disc stroke and a disc accelerator to provide a cracking pressure of 0.3 psig.
   5. The disc accelerator shall be of one piece construction and provide rapid closure of the valve in high head applications. The disc accelerator shall be enclosed within the valve and shall be field adjustable and replaceable without removal of the valve from the line. The disc accelerator shall be securely held in place captured between the cover and disc. It shall be formed with a large radius to allow smooth movement over the disc surface.
   6. The valve disc shall be cycle tested 1 million times in accordance with ANSI/AWWA C508 and show no signs of wear, cracking, or distortion to the valve disc or seat and shall remain drop tight at both high and low pressures.

7. Materials of Construction: All materials of construction shall conform to AWWA C508 and shall be as follows for various valve components:
   a. Body, Cover: Cast Iron ASTM A126 Class B
   b. Body Seat: Type 316 stainless steel ASTM A276
   c. Seat O-Ring: Buna-N Rubber
   d. Seat Pins: Type 316 stainless steel ASTM A276
   e. Disc: Type 316 stainless steel ASTM A276.
   f. Disc Center Pin: Type 316 stainless steel ASTM A276
   g. Cover: Epoxy-Coated Steel ASTM A105
   h. Cover Bolts: Type 316 stainless steel ASTM A276
   i. Cover Bolt Nut: Type 316 stainless steel ASTM A276.
   j. Shaft: Type 316 stainless steel ASTM A276
   k. Washer: Type 316 stainless steel ASTM A276.
   l. Inner Bushings: Bronze ASTM B505 CDA C95400
   m. Outer Bushings: Bronze ASTM B505 CDA 95400
   n. Gland: Cast Iron ASTM A126 Class B
   o. Gland Studs: Type 316 stainless steel ASTM A276.
   p. Gland Packing: Graphite-Kevlar
   q. Plunger: Bronze ASTM B584 CDA C89833
   r. Plunger O-Ring: Buna-N Rubber
   s. Chamber Liner: Bronze ASTM B505 CDA 95400
   t. Adjusting Sleeve: Bronze ASTM B505 CDA 95400
   u. Sleeve Lock Nut: Brass ASTM F467
   v. Lever: Cast Iron ASTM A126 Class B
   w. Counterweight Arm: Cast Iron ASTMA A126 Class B
   x. Cover Plug: Epoxy-Coated Steel ASTM A105
   y. All internal and external bolting and other hardware including pins, set screws, studs, bolts, nuts and washers: Type 316 stainless steel.
   z. All internal surfaces metal surfaces shall be primed and coated with high solids polyamine-epoxy with a total DFT of not less than 20 mils per specification 09960, Painting.
8. Testing:
   a. Test all valves in the shop in conformance with AWWA C508.
   b. Permitted Leakage at Rated Pressures: Zero.
9. Product and Manufacturer: Provide one of the following:
   a. Valmatic Surgebuster®
   b. Or equal.
10. Provide a multiple limit switch on each pump discharge check valve, as shown on the Drawings. Contacts on this switch shall be interlocked to:
    a. Prevent start of motor, unless the valve is closed.
    b. Display an alarm and stop the motor after an adjustable time delay should the check valve fail to open or fail to close.
    c. Display an alarm and stop the motor should the check valve close when the level in the wet well is such that the pump is operating.

d. Limit switch shall be of the precision plunger type with a differential of 1/10-inch or less. Distance between the center of the valve shaft and the plunger of the limit switch shall not be less than the diameter of the valve disc. Limit switch shall indicate that the disc is not more than one degree open, and shall not indicate that the valve is closed until the disc is within 1/4 degree of being completely closed.

e. Assembly shall be suitable to be mounted on an outside weight and lever swing check valve without modification of the valve or piping, and shall provide proper signals to permit the control system to function as described above without causing false pump cutout and alarm indications, when properly adjusted.

f. Mount the assembly on the valve in accordance with the manufacturer's recommendations and instructions and shall make all necessary adjustments to actuate the limit switch to provide the specified functional features.

2.2 SURFACE PREPARATION AND PAINTING

A. Valves, appurtenances, etc., shall receive shop primer and shop finish coating conforming to the requirements of Section 09900, Painting. If any damage to the paint system occurs, the equipment shall be repainted as directed by the ENGINEER.

B. Surface preparation and painting shall conform to the requirements of Section 09900, Painting.

C. All gears, bearing surfaces, machined surfaces and other surfaces which are to remain unpainted shall receive a heavy application of grease or other rust-resistant coating. This coating shall be maintained during storage and until the equipment is placed into operation.

D. Certify, in writing, that the shop primer and shop finish coating system conforms to the requirements of Section 09900, Painting.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install all valves and appurtenances in accordance with manufacturer's instructions and recommendations.

B. Unless otherwise approved by the ENGINEER, install all valves plumb and level. Install valves free from distortion and strain caused by misaligned piping, equipment or other causes.

3.2 FIELD TESTS AND ADJUSTMENTS

A. Adjust all parts and components as required to provide correct operation.

B. Conduct functional field test of each valve in presence of ENGINEER to demonstrate that each part and all components together function correctly.

3.3 MANUFACTURER'S SERVICE

A. A factory trained representative shall be provided for installation supervision, start-up and test services and operation and maintenance personnel training services. The representative shall make a minimum of 1 visits, 2 hours per visit, to the site. The first visit shall be for assistance in the installation of equipment. The second visit shall be for checking the completed installation and start-up of the system. The third visit shall be as described under Section 01821, Instruction of Operations and Maintenance Personnel. Manufacturer's representative shall test operate the system in the presence of the ENGINEER and verify that valves conform to the requirements. Manufacturer’s representative shall revisit the job site as often as necessary until all trouble is corrected and the installation is entirely satisfactory.

B. All costs, including travel, lodging, meals and incidentals, shall be considered as included in CONTRACTOR’S bid price.

+ + END OF SECTION + +

SECTION 15115

BALL VALVES, OPERATORS AND APPURTENANCES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals required to furnish and install all ball valves, operators and appurtenances.
   2. The Work includes, but is not necessarily limited to, all types of valves required for buried, exposed, submerged and other types of piping, except where otherwise specifically included in other Sections.

B. Coordination:
   1. Review installation procedures under other Sections and coordinate with the Work which is related to this Section including buried piping installation, exposed piping installation, site utilities, insulation, heating, ventilating and air conditioning and plumbing.

1.2 QUALITY ASSURANCE

A. Manufacturer's Qualifications:
   1. Manufacturer shall have a minimum of five years experience of producing substantially similar equipment, and shall be able to show evidence of at least five installations in satisfactory operation for at least five years.
   2. Each type of ball valve shall be the product of one manufacturer.

B. Unit Responsibility:
   1. Unit Responsibility shall assigned by the CONTRACTOR as specified in Section 01600, General Equipment Provisions, to the individual valve and gate suppliers for the entire valve or gate assembly, including both the equipment provided under this Section and the associated electric actuators provided under Section 11200, 480 Volt Motor-Operated Valve and Gate Actuators. A Certificate of Unit Responsibility shall be provided.

C. Reference Standards: Comply with applicable provisions and recommendations of the following, except as otherwise shown or specified.
   1. AGMA Standards.
   2. ANSI B16.1, Cast Iron Pipe Flanges and Flanged Fittings.
   3. ANSI B16.4, Cast Iron Fittings.
   4. ANSI B16.5, Steel Pipe Flanges and Flanged Fittings.
   5. API 6D, American Petroleum Institute, Specifications for Pipeline Valves.
   6. ASTM A 48, Specification for Gray Iron Castings.

7. ASTM A 105, Specification for Carbon Steel Forgings for Piping Applications.
8. ASTM A 126, Specification for Gray Iron Castings for Valves, Flanges and Pipe Fittings.
9. ASTM A 216, Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service.
10. ASTM A 307, Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
11. ASTM A 354, Specification for Quenched and Tempered Alloy Steel Bolts, Studs and Other Externally Threaded Fasteners.
12. ASTM A 436, Specification for Austenitic Gray Iron Castings.
13. ASTM A 536, Specification for Ductile Iron Castings.
14. ASTM B 62, Specification for Composition Bronze or Ounce Metal Castings.
15. AWWA C 111, Rubber-Gasket Joints for Ductile-Iron and Gray-Iron Pressure Pipe and Fittings.
16. AWWA C 507, Ball Valves, 6-Inch Through 48-Inch.
17. AWWA C 540, Power Actuating Devices for Valves and Sluice Gates.
18. National Electrical Code (NEC) current adoption.
19. City of Phoenix – Amendments to the National Electrical Code.
20. NEMA, National Electrical Manufacturer's Association.

1.3 SUBMITTALS

A. All submittals are to be in compliance with the requirements of Section 01320 1.4, Submittals.

B. Certificate of Unit Responsibility attesting that CONTRACTOR has assigned, and the supplier accepts unit responsibility in accordance with the requirements of this Section and Section 01600, General Equipment Provisions. No other Submittal material will be reviewed until the certificate has been received and conforms to the specified requirements.

C. Shop Drawings: Submit for approval the following:
1. Manufacturer's literature, illustrations, paint certifications, specifications, detailed drawings, data and descriptive literature on all valves and appurtenances.
2. Deviations from Contract Documents.
3. Engineering data including dimensions, materials, size and weight.
4. Fabrication, assembly and installation drawings.
5. Certificates of compliance with AWWA Standards, where applicable.
6. Corrosion resistance information to confirm suitability of the valve materials for the application. Information on chemical resistance of elastomers shall be furnished from the elastomer manufacturers.
7. Complete manufacturer’s nameplate data of valves and electric actuators.
8. Special tools list.
9. C_v values and headloss curves.

D. Calculations:
   1. Sizing of operating mechanism with extension stems.
   2. Sizing of gear actuators.
   3. Sizing of anchor bolts.

E. Operation and Maintenance Manuals:
   1. Submit complete installation, operation and maintenance manuals including test reports, maintenance data and schedules, description of operation and spare parts information.
   2. Furnish Operation and Maintenance Manuals in conformance with the requirements of Section 01781, Operation and Maintenance Data.

F. Shop Tests:
   1. Test motor operated valves before shipment to ensure that the mechanisms can close the valves in the specified time limit, and for proper seating.
   2. Hydrostatic tests shall be performed, when required by the valve specifications included herein.

G. Certificates: Where specified or otherwise required by ENGINEER, submit test certificates.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Deliver materials to the site to ensure uninterrupted progress of the Work. Deliver anchor bolts and anchorage devices which are to be embedded in cast-in-place concrete in ample time to prevent delay of the Work.

B. Inspect all boxes, crates and packages shall be inspected by upon delivery to the site. CONTRACTOR shall notify ENGINEER of any loss or damage exists to equipment or components. Replace lost equipment or components and repair damage to new condition in accordance with manufacturer's instructions.

C. Store materials to permit easy access for inspection and identification. Keep all materials off the ground, using pallets, platforms or other supports. Protect steel members and packaged materials from corrosion and deterioration.

D. Store all mechanical equipment in covered storage off the ground and prevent condensation and in accordance with the manufacturer's recommendations for long term storage.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General:

1. Valves shall have manufacturer's name and working pressure cast in raised letters on valve body.
2. Manual valve operators shall turn clockwise to close, unless otherwise specified. Valves shall indicate the direction of operation.
3. Manually operated valves, with or without extension stems, shall require not more than a 40-pound pull on the manual operator to open or close a valve against the specified criteria. The gear actuator and the valve components shall be able to withstand a minimum pull of 200 pounds on the manual operator and an input torque of 300 foot pounds to an actuator nut. Manual operators include handwheel, chain, crank, lever and a T-handle wrench.
4. Unless otherwise specified, all flanged valves shall have ends conforming to ANSI B16.1. The pressure class of the flanges shall be equal to or greater than the specified pressure rating of the valves.
5. Buried valves shall have flanged ends with mechanical joint adapters and installed with a flanged adapter or have grooved mechanical couplings. All bolts shall be Type 316 stainless steel.
6. Buried valves shall be provided with adjustable two piece valve boxes and provided with extension stems, operating nuts and covers unless otherwise shown or specified. Extension stems shall terminate 12-inches below finished grade.
7. All bolts, nuts and studs on or required to connect buried or submerged valves shall be Type 316 stainless steel.
8. All bolts and studs embedded in concrete and studs required for wall pipe shall be of Type 316 stainless steel.
9. For stainless steel bolting, except where Nitronic-60 nuts are required, use anti-seize compound, graphite free, to prevent galling. Strength of the joint shall not be affected by the use of anti-seize compound.
10. All other bolts, nuts and studs shall, unless otherwise approved, conform to ASTM A 307, Grade B; or ASTM A 354.
11. Bolts and nuts shall have hexagon heads and nuts.
12. All materials of construction of the valves shall be suitable for the applications as shown on the Drawings.
13. Protect wetted parts from galvanic corrosion due to contact of two different metals.
14. Buried service valves shall be provided with grease filled actuators with position indicators.
15. Gasket material and installation shall conform to manufacturer's recommendations.
16. Identification: Identify each valve 4-inches and larger with a stainless steel manufacturer’s nameplate stamped with the approved designation.

Manufacturer's nameplate shall be permanently fastened to valve body at the factory. Stenciled designations are acceptable for buried valves.

B. Rubber Seated Ball Valves:
   1. General:
      a. Provide valves conforming to AWWA C507 and as specified herein.
      b. Sizes: 6-inch through 48-inch.
      c. Rated Working Pressure: 150 or 250 psig.
      d. Maximum Fluid Temperature: 180°F.
      e. The body shall have full, unobstructed, circular inlet and outlet port diameters equal to the size of the valve.
      f. The valves shall provide drip-tight bi-directional shut-off at the rated pressures.
      g. The valve bodies shall have support legs or pads to support the valve and actuator weight when installed in a horizontal pipeline.
      h. The ball assembly shall be supported by a two-way thrust bearing assembly consisting of a stud and thrust collar in a grease packed cavity suitable for lifetime lubrication.
      i. Valve seats shall seal a full 360 degrees circumference without interruption.
      j. Valve seats shall be field adjustable around the 360 degrees circumference and replaceable without dismantling the operator, shaft or ball.
      k. Packing shall be self-adjusting, chevron type and shall be accessible without having to dismantle the valve.
   2. Materials of Construction: All materials of construction shall conform to AWWA C507 and shall be as follows for various valve components:
      a. Body: Gray iron, ductile iron, or cast steel.
      b. Ball: Gray iron, ductile iron, or cast steel.
      c. Rubber Seats in Body, Bearing Seal O-Rings: Buna-N or other synthetic rubber suitable for the application.
      d. Seating Surface on Ball: Type 316 stainless steel or nickel-chrome.
      e. Shaft: Type 316 stainless steel.
      f. Tapered Pins for Attachment of Shaft to Ball: Type 316 stainless steel.
      g. Bearings: Teflon-lined with fiberglass backing, self-lubricating.
      h. Thrust Collar and Stud Bolt of Thrust Bearing Assembly: Type 316 stainless steel.
      i. Shaft Seals: Self-adjusting V-type chevron packing.
      j. All internal and external bolting and other hardware including pins, set screws, studs, bolts, nuts and washers: Type 316 stainless steel.
   3. Testing:
      a. All valves shall be shop tested in conformance with AWWA C507.
   4. Interior Coating:
      a. All valves shall be coated inside. The steel, cast iron and ductile iron surfaces, except machined surfaces, shall be epoxy coated in accordance with AWWA C550.

5. Product and Manufacturer: Provide one of the following:
   a. Henry Pratt Company.
   b. Jamesbury.
   c. Jenkins.
   d. Or equal.
6. Valve Operator - Manual:
   a. Provide valves with gear actuators conforming to AWWA C507.
   b. Size gear actuators for valves 10-inch and smaller for a differential pressure equal to the rated pressure of the valve and a port velocity of 35 feet per second.
   c. Gear actuators for valves larger than 10-inch shall be sized for maximum differential pressures and flow velocities as specified below:
      1) Maximum Differential Pressure Across Closed Valve: 80 psig.
      2) Maximum Port Velocity through Full Open Valve: 10 ft/s.
   d. Valves shall be equipped with an enclosed worm gear drive and nut, handwheel or chain wheel operator.
   e. Enclosed worm gear operators shall have a gear ratio designed not to exceed 80 pounds pull to meet the required operator torque.
   f. Gears shall be permanently lubricated and totally enclosed.
   g. Operators shall be designed to hold the valve disc in any intermediate position without creeping or fluttering.
   h. Provide adjustable stops to prevent overtravel in either position, to withstand a pull of 200 pounds.
   i. Stops shall be enclosed within the operator housing and shall be capable of absorbing the full operator torque with minimum safety factor of five.
   j. Operators shall be equipped with a direct coupled indicator.
   k. Valves regardless of size, if installed with the operating wheel more than five feet above the operating floor, shall be provided with a chainwheel, sprocket, and aluminum chain. Chain shall extend to three feet above the operating floor.
   l. Valve operator shall be designed to fully close or fully open the valve in a minimum of 30 turns. Valves shall open counter-clockwise, and shall have a position indicator.
   m. Product and Manufacturer: Provide manual operators by one of the following:
      1) Philadelphia Gear Corporation.
      2) Or equal.
7. Pneumatic Cylinder Operator:
   a. Pneumatic operator shall be furnished for open-close operation.
   b. Operators shall be suitable for operating in temperatures ranging from -20 to +160°F.
   c. Mechanism: Operators shall be single-piston, rack-and-pinion type and shall provide a 90-degree rotation of the output shaft.

d. Operators shall be totally enclosed, with no external moving parts, except for the output shaft which shall be accessible for manual operation of the valve.
e. Bearing surfaces, including the inside cylinder wall and guides, shall be coated with a permanent, dry-film lubricant and corrosion inhibitor.
f. Cylinder, end caps and spring cartridge shall be made of precision extruded, hard-anodized aluminum.
g. Pistons shall be made of hard-anodized aluminum alloy and the output shaft and pinion shall be hardened and tempered alloy steel. Piston seals shall be O-ring type.
h. Operators shall be suitable for use with nonlubricated dry instrument quality air at up to 120 psig.
i. Operators shall have internal porting with no external piping.
j. Mounting: The operator output shaft shall attach directly to the valve stem with no intermediate linkages. Operators shall be suitable for operation in any valve mounting position and either parallel or perpendicular to the pipe.
k. Limit switches or position indicator furnished shall have two dry contacts. One contact actuates the valve opened, one at valve closed. Limit switches shall be supplied in a NEMA 7 explosion-proof enclosure.
l. Product and Manufacturer: Provide one of the following:
   1) Fisher Controls International, Inc.
   2) Or equal.

8. Shop Painting:
   a. Interior ferrous metal surfaces of the valve except finished or bearing surfaces shall be shop painted with two coats of an approved two component coal tar epoxy coating applied in accordance with the manufacturer's recommendations.
   b. Exterior surfaces of the valve and operator shall be shop painted as specified hereinafter under Article 2.8, below.

2.2 APPURTENANCES FOR EXPOSED VALVES

A. General:
   1. For valves located less than 5 feet- 0 inches above the operating floor, provide levers on 4-inch quarter turn valves and handwheels on all other valves, unless otherwise shown on the Drawings or specified.
   2. For valves located at 5 feet-0 inches or more above the operating floor, provide chain operators.
   3. Where shown on the Drawings, provide extension stems and floorstands.

B. Handwheels:
   1. Conform to the applicable AWWA Standards.
   2. Material of Construction: Ductile iron or cast aluminum.

3. Arrow indicating direction of opening and word "OPEN" shall be cast on the trim of the handwheel.
4. Maximum Handwheel Diameter: 30-inches.

C. Chain Operators:
1. For valves more than 5 feet-0 inches above the operating floor provide chain operators.
2. Chains shall extend to three feet above the operating floor.
3. A 1/2-inch stainless steel hook bolt shall be provided to keep the chain out of the walking area.
4. Materials of Construction:
   a. Chain: Stainless steel.
   b. Chain wheel: Recessed groove type made out of bronze bushed with guides.
5. Chain Construction:
   a. Chain shall be of welded link type with smooth finish. Chain that is crimped or has links with exposed ends shall not be acceptable.
6. Provide geared operators where required to position chain wheels in vertical position.

D. Crank Operator:
1. Crank operator shall be removable and fitted with a rotating handle.
2. Maximum Radius of Crank: 15-inches.
3. Materials:
   a. Crank: Cast iron or ductile iron.
   b. Handle: Type 304 stainless steel.
   c. Hardware: Type 304 stainless steel.

E. Extension Stems and Floorstands for Valves:
1. Conform to the applicable requirements of AWWA C501 for sizing of the complete lifting mechanism.
2. Bench and Pedestal Floorstands:
   a. For valves requiring extension stems, provide bench or pedestal floorstands with handwheel or crank as indicated. Make provisions for use of portable electric actuator for opening and closing of the valves.
   b. Type: Heavy-duty with tapered roller bearings enclosed in a weatherproof housing, provided with positive mechanical seals around lift nut and pinion shaft to prevent loss of lubrication and to prevent moisture from entering the housing. A lubrication fitting shall be provided for grease. The base shall be machined.
   c. Materials of Construction:
      1) Housing: Cast-iron, ASTM A 126, Class B, or steel.
      2) Lift Nut: Cast bronze, ASTM B 98.
      3) Grease Fitting: Stainless steel.
      4) All Bolting: Type 316 stainless steel.

3. Wall brackets for floorstands shall be of Type 316L stainless steel construction.
4. Extension Stems:
   a. Materials of Stems and Stem Couplings: Type 316 stainless steel.
   b. Maximum Slenderness Ratio (L/R): 100.
   c. Minimum Diameter: 1.5 inch.
   d. Threads: ACME.
   e. Stem couplings shall be provided where stems are furnished in more than one piece. The couplings shall be threaded and keyed or threaded and bolted and shall be of greater strength than the stem.
   f. A Type 316 stainless steel cap suitable for the square end of the valve stem shall be welded to the bottom of the extension stem.
5. Bottom Couplings: Ductile iron with Type 316 stainless steel pin and set screw.
6. Stem Guides:
   a. Material: Type 316 cast stainless steel with bronze bushing for stem.
   b. Maximum Stem Length between Guides: Seven feet.
   c. Stem guides shall be adjustable in two directions.

F. Floor Boxes: Provide cast iron floor boxes for all valves which are to be operated from floor above valve. Boxes shall be equal in depth to floor slab. Boxes shall have cast iron covers and be fitted with bronze bushing.

2.3 APPURTENANCES FOR BURIED VALVES

A. Wrench Nuts:
   1. Provide wrench nuts on all buried valves of nominal 2-inch size conforming to AWWA C500.
   2. Arrow indicating direction of opening the valve shall be cast on the nut along with the word "OPEN".
   3. Material: Ductile iron.
   4. The nut shall be secured to the stem by mechanical means.

B. Extension Stems for Non-Rising Stem Valves and Quarter Turn Buried Valves:
   1. Provide extension stems to bring the operating nut to 6-inches below the valve box cover.
   2. Minimum Size and Material: Same as valve stem.
   3. Maximum Unsupported Length: Three feet.
   4. Provide top nut and bottom coupling of ductile iron with pins and set screws of Type 316 stainless steel.

C. Valve Boxes:
   1. Valve boxes shall be as shown on the Drawings and as required.
   2. Type: Heavy duty, suitable for highway loading, 2-piece telescopic, and adjustable. Lower section shall enclose operating nut and stuffing box and rest on bonnet.
   3. Material: Cast or ductile iron.

4. Coating: Two coats of asphalt varnish conforming to Federal Specification TT-C-494.
5. Marking: As required for service.

2.4 ANCHOR AND MISCELLANEOUS MOUNTING BOLTS

A. All bolts, nuts and washers for connection of the valve appurtenances to concrete structure or other structural members shall be obtained from the valve manufacturer, and shall be of ample size and strength for the purpose intended. Anchor bolts shall be hooked or adhesive type and shall be Type 316 stainless steel.

B. Provide anchor bolts for stem guides of required strength to prevent twisting or sagging of the guides under load.

C. Provide bolts and washers of Type 316 stainless steel and nuts of Nitronic 60. The bolts shall have rolled threads and both bolts and nuts shall be electropolished to remove burrs.

D. Minimum Size of Anchor Bolts: 5/8-inch.

2.5 TOOLS AND SPARE PARTS

A. Provide the following T-Handle Operating Wrenches for Buried Valves:
   1. Length of T-Handle Operating Wrench: 2-ft.
   2. Quantity: 2.

2.6 SURFACE PREPARATION AND PAINTING

A. Valves, appurtenances, etc., shall receive shop primer and shop finish coating conforming to the requirements of Section 09900, Painting. If any damage to the paint system occurs, the equipment shall be repainted as directed by the ENGINEER.

B. Surface preparation and painting shall conform to the requirements of Section 09900, Painting.

C. All gears, bearing surfaces, machined surfaces and other surfaces which are to remain unpainted shall receive a heavy application of grease or other rust-resistant coating. This coating shall be maintained during storage and until the equipment is placed into operation.

D. Certify, in writing, that the shop primer and shop finish coating system conforms to the requirements of Section 09900, Painting.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation shall be as specified herein. Valve operators shall be located so that they are readily accessible for operation and maintenance. Valve operators shall be mounted for unobstructed access, but mounting shall not obstruct walkways. Valve operators shall not be mounted where shock or vibration will impair their operation. Support systems shall not be attached to handrails, process piping or mechanical equipment.

B. Computerized Maintenance Management System Tags shall be securely attached to the operator in a readily visible location. Refer to Section 01630.2.1.C, for guidance.

C. Install all valves and appurtenances in accordance with manufacturer's instructions and recommendations.

D. Install all valves so that operating handwheels or wrenches may be conveniently turned from operating floor, but without interfering with access, and as approved by ENGINEER.

E. Unless otherwise approved, install all valves plumb and level. Install valves free from distortion and strain caused by misaligned piping, equipment or other causes.

F. Set valve boxes plumb, and centered with the bodies directly over the valves. Carefully tamp earth fill around each valve box to a distance of four feet on all sides of the box, or to the undisturbed trench face, if less than four feet.

3.2 FIELD TESTS AND ADJUSTMENTS

A. Adjust all parts and components as required to provide correct operation of the valves.

B. Conduct a functional field test on each valve in the presence of the ENGINEER to demonstrate that each valve operates correctly.

C. Demonstrate satisfactory opening and closing of valves at the specified criteria requiring not more than 40 pounds effort on the manual actuators.

D. Test ten percent valves of each type by applying 200 pounds effort on the manual operators. There shall be no damage to the gear actuator or the valve.

E. For motor operated valves, perform all field tests and adjustments required under Section 11200, 480 Volt Motor-Operated Valve and Gate Actuators.

3.3 MANUFACTURER'S SERVICES

A. A factory trained representative shall be provided for installation supervision, start-up and test services and operation and maintenance personnel training services. The representative shall make a minimum of 1 visits, minimum 2 hours on-site for each visit, to the site. The first visit shall be for assistance in the installation of equipment. The second visit shall be for checking the completed installation and start-up of the system. The third visit shall be as described under Section 01821, Instruction of Operations and Maintenance Personnel. Manufacturer's representative shall test operate the system in the presence of the ENGINEER and verify that the valves conform to requirements. Manufacturer's representative shall revisit the job site as often as necessary until all trouble is corrected and the installation is entirely satisfactory.

B. All costs, including travel, lodging, meals and incidentals, shall be considered as included in CONTRACTOR'S bid price.

+ + END OF SECTION + +

SECTION 15119

SPECIALTY VALVES AND APPURTENANCES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals required to furnish and install all specialty valves and appurtenances complete and operational as shown on the Drawings and as specified.
   2. The Work includes, but is not necessarily limited to, all types of valves required for buried, exposed, submerged and other types of piping, except where otherwise specifically included in other Sections.

B. Coordination:
   1. Review installation procedures under other Sections and coordinate with the Work which is related to this Section including buried piping installation, exposed piping installation, site utilities, insulation, heating, ventilating and air conditioning and plumbing.

1.2 QUALITY ASSURANCE

A. Manufacturer's Qualifications:
   1. Manufacturer shall have a minimum of five years experience of producing substantially similar equipment, and shall be able to show evidence of at least five installations in satisfactory operation for at least five years.
   2. Each type of specialty valve shall be the product of one manufacturer.

B. Reference Standards: Comply with applicable provisions and recommendations of the following, except as otherwise shown or specified.
   1. ANSI A13.1, Scheme for Identification of Piping Systems.
   2. ANSI/ASME A112.1.2, Air Gaps in Plumbing Systems.
   3. ANSI B16.1, Cast Iron Pipe Flanges and Flanged Fittings.
   4. ANSI B16.4, Cast Iron Fittings.
   5. ANSI B40.1, Gauges-Pressure Indicating Dial Type-Elastic Element.
   6 ASTM A 48, Specification for Gray Iron Castings.
   7. ASTM A 126, Specification for Gray Iron Castings for Valves, Flanges and Pipe Fittings.
   8. ASTM A 240, Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet and Strip for Pressure Vessels.
   9. ASTM A 307, Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.

10. ASTM A 354, Specification for Quenched and Tempered Alloy Steel Bolts, Studs and Other Externally Threaded Fasteners.
11. ASTM A 436, Specification for Austenitic Gray Iron Castings.
12. ASTM A 536, Specification for Ductile Iron Castings.
13. ASTM B 62, Specification for Composition Bronze or Ounce Metal Castings.
14. ASTM D 1784, Specification for Rigid Poly (Vinyl Chloride) PVC Compounds and Chlorinated Poly (Vinyl Chloride) CPVC compounds.
15. ASTM D 1785, Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedulers 40, 80 and 120.
16. AWWA C111, Rubber-Gasket Joints for Ductile-Iron and Gray-Iron Pressure Pipe and Fittings.
17. AWWA C500, Gate Valves for Water and Sewerage Systems.
18. AWWA C502, Dry-Barrel Fire Hydrants.
19. AWWA C503, Wet-Barrel Fire Hydrants.
20. AWWA C506, Backflow Prevention Devices - Reduced Pressure Principle and Double Check Valve Types.
21. AWWA C507, Ball Valves, 6-Inch Through 48-Inch.
22. AWWA C508, Swing Check Valves for Waterworks Service, 2-inch through 24-inch NPS.
23. AWWA C509, Resilient-Seated Gate Valves, 3 through 12 NPS, for Water and Sewerage Systems.
24. AWWA C512 Air-Release, Air/Vacuum and Combination Air Valves for Water Works Service
25. AGMA Standards.
26. ASSE 1003, Water Pressure Reducing Valves.
27. NEMA, National Electrical Manufacturer's Association.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Manufacturer's literature, illustrations, paint certifications, specifications, detailed drawings, data and descriptive literature on all valves and appurtenances.
   2. Deviations from Contract Documents.
   3. Engineering data including dimensions, materials, size and weight.
   4. Fabrication, assembly, installation and wiring diagrams.

B. Operation and Maintenance Manuals:
   1. Submit complete installation, operation and maintenance manuals including test reports, maintenance data and schedules, description of operation, and spare parts information.
   2. Furnish Operation and Maintenance Manuals in conformance with the requirements of Section 01781, Operation and Maintenance Data.

C. Shop Tests:
   1. Test motor operated valves before shipment to ensure that the mechanisms can close the valves in the specified time limit, and for proper seating.
   2. Hydrostatic tests shall be performed, when required by the valve specifications included herein.

D. Certificates:
   1. Where specified or otherwise required by ENGINEER, submit test certificates.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Deliver materials to the site to ensure uninterrupted progress of the Work. Deliver anchor bolts and anchorage devices, which are to be embedded in cast-in-place concrete, in ample time to not delay the Work.

B. All boxes, crates and packages shall be inspected by CONTRACTOR upon delivery to the site. Notify ENGINEER if any loss or damage exists to equipment or components. Replace loss and repair damage to new condition, in accordance with manufacturer's instructions.

C. Store materials to permit easy access for inspection and identification. Keep all material off the ground, using pallets, platforms or other supports. Protect steel members and packaged materials from corrosion and deterioration.

D. Store all mechanical equipment in covered storage off the ground and prevent condensation and in accordance with the manufacturer's recommendations for long term storage.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General:
   1. Valves shall have manufacturer's name and working pressure cast in raised letters on the valve body or on a stainless steel manufacturer's nameplate stamped with the approved designation and permanently attached to the valve body.
   2. Manual valve operators shall turn clockwise to close, unless otherwise specified. Valves shall indicate the direction of operation.
   3. Unless otherwise specified, all flanged valves shall have ends conforming to ANSI B16.1. The pressure class of the flanges shall be equal to or greater than the specified pressure rating of the valves and piping.
   4. Buried valves shall have flanged ends with mechanical joint adapters and installed with a flanged adapter or have grooved mechanical couplings. All bolts shall be Type 316 stainless steel.

5. Buried valves shall be provided with adjustable two piece valve boxes and provided with extension stems, operating nuts and covers, unless otherwise shown or specified. Extension stems shall terminate 12-inches below finished grade.
6. All bolts, nuts and studs on or required to connect buried or submerged valves shall be Type 316 stainless steel.
7. All bolts and studs embedded in concrete and studs required for wall pipe shall be of Type 316 stainless steel.
8. For stainless steel bolting, except where Nitronic-60 nuts are required, use anti-seize compound, graphite free, to prevent galling. Strength of the joint shall not be affected by the use of anti-seize compound.
9. All other bolts, nuts and studs shall, unless otherwise approved, conform to ASTM A 307, Grade B; or ASTM A 354.
10. Bolts and nuts shall have hexagon heads and nuts.
11. Gasket material shall be viton and installation shall conform to manufacturer's recommendations.
12. Identification: Identify each valve 4-inches and larger with a stainless steel manufacturer's nameplate stamped with the approved designation. Manufacturer's nameplate shall be permanently fastened to valve body at the factory. Stenciled designations are acceptable for buried valves.
13. All materials of construction of the valves shall be suitable for the applications as shown on the Drawings.
14. Protect wetted parts from galvanic corrosion due to contact of two different metals.

B. Pressure Relief Valves (1-inch and smaller) – (Blow-off Valve):
1. Pressure relief valves on air supply piping and surge tank air relief shall be of bronze construction, with a ½-inch inlet or as shown on the Drawings. Set valve to open at 150psig.
2. Spring: Type 316 stainless steel
3. Diaphragm: air stream – Type 316 stainless steel
4. Trim: Type 316 stainless steel
5. Product and Manufacturer: Provide one of the following:
   a. Mueller Company
   b. Watts Regulator
   c. Fischer 98 Series
   d. Or Approved Equal

C. Pressure Relief Valves (2-inch and larger):
1. The High Pressure Relief Valve shall be a globe type and function to open rapidly at predetermined overpressure and close slowly after restoration of normal pressure. Set valve to open at 150psig.
2. Each pressure relief valve shall open rapidly and close slowly at a predetermined rate of speed.
3. Valve design shall include provisions to regulate closing speed.

4. Provide limit switches with open and closed position indicators. See Electrical and Instrumentation Drawings.
5. Design: 300 pound flanged glove valve type.
6. Body and Cover: Type 316 stainless steel
7. End Connections: Flanged, ANSI B 16.1.Class 300
8. Seals: Buna-N
9. Diaphragm: Neoprene
10. Main Valve Trim: Type 316 stainless steel.
11. Pilot Control System: Stainless Steel; Normally Closed (NC) Solenoids provided for open/close function only.
12. Coating: High Solids Prime and Finish Coats in accordance with Section 09900, Painting.
13. Product and Manufacturer: Provide on of the following:
    a. Bermad Model 730-55-NC-SS-U
    b. Cla-Vla Model 650
    c. Ames
    d. Or Approved Equal

D. Hose Bibbs, Pipe Drains:
1. Valve:
    a. Type: Boiler drain globe valve, chrome plated.
    b. Material: Bronze body, screwed bonnet, renewable composition disc.
    c. End Connections: Hose thread outlet, male pipe thread or sweat inlet.
    d. Rating: 125 lbs. WOG.
2. Vacuum Breaker:
    a. Type: Non-removable, atmospheric.
    b. Materials: Brass body, stainless steel trim, silicone rubber diaphragm and disc.
    c. End Connections: Hose thread inlet and outlet.
3. As manufactured by one of the following:
    a. Woodford Manufacturing Co.
    b. Nibco Incorporated.
    c. Or Approved Equal.

E. Pipe Labels:
1. Type: Self-adhering, temperature resistant, waterproof, corrosion resistant.
2. Marker size, marker color, legend size, and legend color shall conform to ANSI A13.1.

F. Flexible Connections:
1. Type: Flexible connections for piping 2-1/2-inches and smaller:
2. Construction:
    a. Hose: Bronze.
    b. Braid: Bronze.
3. Pressure Ratings: 190 psig working pressure at 250°F temperature.

4. End Connections: Solder end welded to hose and braid ends.
5. Product and Manufacturer: Provide one of the following:
   a. Flexonics Incorporated.
   b. Anaconda Metal Hose Division, Anamet Incorporated.
   c. Or equal.

H. Emergency Shower and Eyewash Station:
1. Emergency Shower and Eyewash:
   a. Type: Free standing corrosion resistant emergency shower and eyewash station.
   b. Materials:
      1) Shower: 9-inch diameter cycolac plastic shower head with 1-1/2-inch stay-open stainless steel ball valve and 24-inch rigid pull rod.
      2) Eye/Face-Wash: Cycolac bowl with twin Buna-N covered ABS heads and stainless steel ball valve, stay open type.
      3) Pipe: All PVC parts shall be Schedule 80, painted safety yellow and green.
      4) Supply: 1-1/4-inch PVC.
   c. As Manufactured by one of the following:
      1) Haws Axion MSR combination shower eye/face wash model 8309WC.
      2) Speakman Co., Model SE-580.
      3) Or equal.
2. Flow Switches, Audible and Visible Alarms:
   a. Type: Double pole, double throw, NEMA 4X, UL listed paddle type flow switch. Contacts to be rated for five amps at 120 volts.
   b. Flow switches shall be furnished by emergency shower and eyewash manufacturer at each shower and/or eyewash station. Shower flow switch shall be rated for 25 to 30 gpm flow and eyewash flow switch shall be rated for 0.3 to 3 gpm flow
   c. Flow switches shall sense flow for showers and eyewashes. Flow switches shall be full line size so as not restrict water flow in order to detect flow. Provide separate flow switch for shower and eyewash, as required at each emergency shower and eyewash station.
   d. Visible alarm shall be an amber flashing light, UL listed, and shall be provided under Division 16, Electrical.
   e. Audible alarm shall be an intermittent signal rated at 90 db at ten feet and shall be provided under Division 16, Electrical.
   f. Each emergency shower station shall be furnished with a shower and eyewash test kit.
   g. As manufactured by one of the following:
      1) Haws.
      2) Speakman Co.
      3) Or equal.

3. Safety Valve Lockout with Padlock:
   a. Heavy duty plastic, dielectric and chemical resistant valve lock.
   b. Padlock with unique serial number, hardened steel shackle, two brass keys with matching serial numbers for each padlock.
   c. Product and Manufacturer: Provide one of the following:
      1) Akron, Safety Products, Inc.
      2) Brady USA, Inc.
      3) Or equal.
4. Anti-Scald Valves:
   a. Anti-scald valve provides scald protection and bleeds valve whenever internal temperature rises above 100°F and closes when line temperature drops to 85°F.
   b. Product and Manufacturers: Provide one of the following:
      1) Haws Drinking Faucet Co., Model SP157A Scald-Protection Valve.
      2) Speakman Co.
      3) Or equal.
5. The supply piping shall be insulated conforming to the requirements of Section 15082, Insulation of Piping and Equipment - HVAC and Process.

I. Quick Coupler Connections:
1. Type: Cam arms lock into adaptor groove.
2. Materials: Adaptor and Coupler:
   a. Body: Stainless steel.
   b. Cam arms: Stainless steel.
   c. Gaskets: Buna N.
3. Ends: Socket weld quick connect adaptor for connection to copper tubing; hose shank quick connect coupler.
4. Reference: MIL-C-27487.
5. As Manufactured by one of the following:
   a. Dover Corp.; OPW “Kamlok” series.
   b. Or equal.

J. Trap Primer Valve:
1. Type: Automatic trap priming assembly with timer, solenoid valve and air-gap device to automatically prime traps at set time intervals regardless of trap primer device location.
2. Description: An electronically activated trap priming device. Primer functions at a pre-selected time, delivering water across an air gap funnel.
3. Construction:
   a. Body: Brass
   b. Seals: O-ring 40°F to 450°F.
   c. Inlet and Outlet Size: 1/2-inch.
   d. Air gap device.
   e. Solenoid valve: 115 VAC, 6.3 watts, 60 Hz, Normally Closed.
   f. Provide multiple outlet distribution units as required.

g. Reference: ANSI/ASME A112.1.2 Air Gap in Plumbing Systems Standard.
h. Accessories: Floor drain trap primer distribution unit, a timer set to operate for six seconds every 24 hours.

4. As Manufactured by one of the following:
   a. Precision Plumbing Products, Solo-Prime Electronic Trap Priming Assembly.
   b. Or equal.

K. Hydrants:
   1. Post:
   a. Post hydrants system shall be of the non-freezing exposed head type.
   b. Provide post hydrants with a concrete protective base as specified.
   c. Depth of bury shall be a minimum of 36-inches.
   d. Provide each post hydrant on a non-potable water system with an engraved lamacoid warning sign rigidly attached to or at the hydrant. The sign shall be approximately 5-inches by 2-inches with red letters on a white background and shall read "NON-POTABLE WATER - DO NOT DRINK."
   e. Hydrants shall open counter-clockwise.
   f. Product and Manufacturer: Provide one of the following;
      1) Zurn.
      2) J.R. Smith.
      3) Or equal.
   2. Fire:
   a. Fire Hydrants shall be designed, manufactured, and tested in compliance with the latest edition of the American Water Works Association (AWWA) - C. 502
   b. Detail drawings or blue prints showing all components, principal dimensions, construction details and materials used shall be submitted.
   c. The diameter of the main valve seat opening shall be not less than 5 inches in diameter. The entire valve assembly shall be effectively sealed against moisture.
   d. All interior ferrous surfaces of the shoe exposed to fluid flow (including the valve plate and cap nut), shall be epoxy coated to a minimum dry thickness of 6 mils. Epoxy coatings shall be factory applied by an electrostatic or thermosetting process in accordance with the manufacturer's printed instructions. The epoxy materials used shall be 100% powder epoxy or liquid epoxy that conforms to the requirements of AWWA C-550-81, NSF 61 approved, and to the prevailing requirements of the Food and Drug Administration and of the Environmental Protection Agency.
   e. Style of inlet shoe connections shall be a restrained mechanical joint with accessories, gland, bolts, gaskets and having a 6 inch diameter inlet connection.
   f. Solid flange or ring tight "bump in" connections will not be allowed unless through exception by owner.

g. Facing of the main valve against seats shall be rubber or synthetic rubber.
h. The top of the stem or bonnet shall be equipped with the O-ring seal.
i. Hydrants shall be constructed so that extension sections in multiples of 6 inches, with rod and coupling, can be added to increase barrel length.
j. The hose and steamer nozzle connections and size shall be per the latest Maricopa Association of Governments (MAG).
k. Operating and outlet nozzle cap nuts shall be of solid pentagonal shape. The pentagon shall measure fifteen-sixteenths to thirty-one thirty-seconds inch on side, 1 1/2 inch from point to flat.
l. The outside of the hydrant top section shall be painted a minimum of one coat of non- lead base premium primer and two (2) finished coats of non-lead base premium durable paint. The surface will be properly prepared, smooth, clean, and dry before primer is applied. The primer coat will be applied to a DFT (Dry Film Thickness) of 3-4 mils. The final 2 coats will be applied to achieve a DFT of 6-8 mils on top of the primer coat. Paint will be a semi-gloss, bright chrome safety yellow in color or as specified by owner. Paint will have high color retention. Paint will be fade and UV resistant, rust resistant, resistant to abrasions and chipping and have flexibility qualities.
m. Hydrants shall be constructed so that the standpipe can be rotated 360 degrees to at least 8 different positions.
n. Hydrants shall be designed for a 250 psi working pressure and factory bench tested to a 500 psi hydrostatic pressure.
o. Hydrants shall be of the break flange traffic model type with a replaceable breakable unit immediately above the ground line to minimize repairs necessary due to traffic damage. The breakable stem coupling will be made of a corrosion resistant material such as stainless steel or bronze, or have a permanently applied non corrosive finish such as nickel plating or fusion bonded epoxy coating.
p. Hydrants shall be of the compression type; constructed such that the main valve closes with the water pressure to assure no loss of water in the event of damage to the upper portion of the fire hydrant.
q. Main valve opening shall have a minimum diameter of 5-inches to assure optimum flow. Facing of the main valve against the seats shall be of rubber or synthetic rubber minimum of 1 inch in thickness. Plastic or Neoprene type main valves will not be allowed.
r. Hydrants shall be of the dry top design with o-ring seals to ensure that the operating threads will be protected from water entry. Dry top design to include factory-lubricated operating mechanism which allows supplemental lubricant to be added in the field without removal of the upper barrel. Standard lubricant shall be a NSF 61 approved oil or grease suitable for a temperature range of 20 degrees to 150 degrees F.
s. Hydrants shall have a cast iron weather shield at the operating nut to protect the clearance area between the top casting and the operating nut.

t. The operating nut shall be a one-piece bronze casting. Both the operating nut and the nozzle cap nuts shall be National Standard Pentagon in shape and measure 1-1/2 inches from point to flat at the base of the nut.
u. Hydrants shall have two hose nozzles, 2.5 inches in diameter, and one "pumper" nozzle approved by the Owner. Rubber gasket nozzle caps shall be provided. Screw Threads shall be per owner requirements.
v. Hydrant nozzle section shall be capable of rotation through 360 degrees to at least 8 points of rotation with respect to the standpipe to allow the positioning of the hose or "pumper" nozzles
w. Minimum distance allowable between the centerline of the lowest nozzle and ground / bury line is 18-inches. Bury line shall be visibly marked on lower barrel of hydrant.
x. Hydrants shall have markings indicating direction of opening right to left (counter-clockwise).
y. Hydrants shall have permanent markings identifying the manufacturer name, model identification, size of the main valve opening and the year of manufacture.
z. Hydrants shall have an automatic drain that is operated by the main valve rod. The drain valve is to open as the main valve is closed and close as the main valve is opened. The port and seat of the drain valve shall be bronze. Drain facings shall not be leather.
aa. Hydrants shall have a bronze valve seat and shall be threaded into a bronze drain ring or shoe bushing to prevent electrolysis between these components.
ab. Hydrants shall be designed to permit the use of extension sections.
ac. Hydrants shall be designed to allow all working parts to be removed through the bonnet/dome or upper nozzle section of the hydrant without removal of the entire upper barrel section.
ad. All nuts and bolts of the factory hydrant to be buried below ground will be a minimum of 304 stainless steel and coated for gall protection.
ae. Hydrants shall be suitable for installation in 36-inch to 72-inch trench depth or as specified by owner.
af. The manufacturer shall guarantee that the hydrant is so constructed that the valve stem will not be bent when hydrant is damaged or broken at or near the grade level. A safety breaking flange or thimble shall be provided. The friction loss must be guaranteed, by the manufacturer, to satisfy Table 2.1.S.2.af – 1

TABLE 2.1.S.2.af - 1			
MAXIMUM PERMISSIBLE LOSS OF HEAD FOR HYDRANTS			
Number of Outlet Nozzles	**Nominal Diameter of Outlet**	**Total Flow From Outlet Nozzles GPM**	**Maximum Permissible Head Loss PSI**
2	2 1/2 inches	500	2.0
1	4 inches	600	2.5

ag. All items shall be warranted by the manufacturer for a minimum period of five (5) years from date of acceptance by the Owner, against defects in material and workmanship. At any time during that period, if a defect should occur in any item, it shall be repaired or replaced by the manufacturer at no obligation to the Owner, except where it would be shown that the defect was caused by misuse and not by fault of manufacturer. The manufacturer shall make necessary repairs within the time frame specified by the owner or reimburse the owner if emergency repairs are required. The manufacturer expressly warrants all items to be new, free from defect in design, materials, and workmanship and to be fit and sufficient for their intended purpose. All warranties shall survive acceptance and payment by the city.

ah. All items shall be inspected before acceptance by an authorized representative of the Owner for workmanship, acceptance and proper functioning of components, and conformance to all requirements of this specification. Should deficiencies be found, it shall be the responsibility of the supplier to pack the item(s) in question, make necessary corrections, and then return to the Owner for re-inspection and acceptance at no additional expense or obligation to the Owner.

ai. Nozzle thread requirements – Refer to Phoenix Standard Detail (P1361) to the MAG Specification.

aj. Depth of bury shall be a minimum of 42-inches. Refer to Phoenix Standard Detail (Detail to be revised 2009) to the MAG Specification (exceptions to bury depth requirements allowed only by Water Services Department permission).

ak. Product and Manufacturer: Provide one of the following;
1) Mueller Super Centurion 250
2) Clow Medallion (new model)
3) Kennedy K-81 Guardian
4) American Darling B-84-B
5) East Jordan Iron Works CD-250

L. Combination Vacuum/Air Release Valves:
1. Construction:
a. Air valves for water service shall meet AWWA C512-15, latest edition, Standard for Air-Release, Air/Vacuum and Combination Air Valves for Water and Wastewater Service.
b. Purpose: The combination air release valve allows large volumes of air to escape out of the large orifice when filling a pipeline and closes when liquid enters the air and vacuum valve. In addition, they will automatically release small pockets of air from a pipeline under pressure like an air release valve.
c. Operation: Float actuated valve with large orifice exhausts or admits air from the system, with small venting orifice discharges accumulated air or vapor to atmosphere with the system under pressure.
d. The entire float and baffle assembly must be shrouded with a double acting throttling device which allows air to be throttled when venting and non-restrictive when entering. This device shall prevent water from slamming the float shut and damage to the valve while allowing for full air entry to prevent damage by vacuum. Outlets shall be threaded.
e. The float seat for wastewater service shall seal at pressures equal to 0.3psig.
f. Provide connection piping between air valve and isolation valve. Diameter size shall match air release valve NPT connection. Connection piping material shall be Type 316 stainless steel.
g. Materials of construction shall be as follows:
1) Body configuration for wastewater services shall be Single Body Combination Vacuum/ Air Release Valve
a) Body: ASTM A744 CF8M with electroless nickel
b) Cover: ASTM A744 CF8M with electroless nickel
c) Float Type: Polypropylene
d) Air & Vacuum Seal: Viton
e) Air Release Seal: Viton
f) Spring: Type 316 Stainless Steel
g) O-Rings: Viton
h) Outlet size/connection: as indicated on the Drawings
2. As Manufactured by One of the Following:
a. ARI Flow Control Accessories
b. Or equal.

M. Surge Relief Valves for Wastewater Service:
1. General:
a. The surge relief valves shall function to open on excessive line pressures and exhaust air.
b. Surge relief valves shall open rapidly and close slowly at a predetermined rate of speed.
c. Valve design shall include provisions to regulate closing speed.

d. Surge relief valves shall be suitable for wastewater service with the specified water quality.
e. All wetted materials shall be Type 316 stainless steel.

2. Construction:
   a. Design: Globe surge relief valves shall be of the weight, lever and hydraulic cylinder type.
   b. Construction and Materials:
      1) Body and Cover: Type 316 Stainless Steel.
      2) Disc Seat: UHMWPE
      3) Body Seat Ring: Type 316 Stainless Steel.
      4) Disc: Type 316 Stainless Steel.
      5) Pivot Shaft: Type 316 Stainless Steel.
      6) External Fasteners: Type 316 Stainless Steel.
      7) Springs: Type 316 Stainless Steel.
      8) Orientation: Long radius elbow body.
      9) Valve to open immediately when system pressure exceeds normal operating pressure by 10 percent. As the system pressure returns to normal the surge relief valve shall close slowly by means of the hydraulic cylinder.
      10) Connection Type and Size: As indicated on the drawings.
3. As manufactured by one of the following:
   a. Val-Matic
   b. APCO

2.2 SURFACE PREPARATION AND PAINTING

A. Valves, appurtenances, etc., shall receive shop primer and shop finish coating conforming to the requirements of Section 09900, Painting. If any damage to the paint system occurs, the equipment shall be repainted as directed by the ENGINEER.

B. Surface preparation and painting shall conform to the requirements of Section 09900, Painting.

C. All bearing surfaces, machined surfaces and other surfaces which are to remain unpainted shall receive a heavy application of grease or other rust-resistant coating. This coating shall be maintained during storage and until the equipment is placed into operation.

D. Certify, in writing, that the shop primer and shop finish coating system conforms to the requirements of Section 09900, Painting.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install all valves and appurtenances in accordance with manufacturer's instructions and recommendations.

B. Install all valves so that operating handwheels or wrenches may be conveniently turned from operating floor but without interfering with access, and as approved by ENGINEER.

C. Unless otherwise approved by the ENGINEER, install all valves plumb and level. Install valves free from distortion and strain caused by misaligned piping, equipment or other causes.

3.2 FIELD TESTS AND ADJUSTMENTS

A. Adjust all parts and components as required to provide correct operation.

B. Conduct functional field test of each valve in presence of ENGINEER to demonstrate that each part and all components together function correctly.

3.3 MANUFACTURER'S SERVICE

A. A factory trained representative shall be provided for installation supervision, start-up and test services and operation and maintenance personnel training services. The representative shall make a minimum of 2 visits, 4 hours per visit, to the site. The first visit shall be for assistance in the installation of equipment. The second visit shall be for checking the completed installation and start-up of the system. The third visit shall be as described under Section 01821, Instruction of Operations and Maintenance Personnel. Manufacturer's representative shall test operate the system in the presence of the ENGINEER and verify that the valves conform to the requirements. Manufacturer's representative shall revisit the job site as often as necessary until all trouble is corrected and the installation is entirely satisfactory.

B. All costs, including travel, lodging, meals and incidentals, shall be considered as included in CONTRACTOR'S bid price.

+ + END OF SECTION + +

SECTION 15120

PIPING SPECIALTIES AND ACCESSORIES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish and install all piping specialties and accessories. Included, but not limited to, are: flexible couplings, mechanical couplings, flanged and harnessed adapters, and expansion joints.

1.2 QUALITY ASSURANCE

A. Manufacturer's Qualifications:
   1. Manufacturer shall have a minimum of five years experience of producing substantially similar types of piping specialties specified and shall be able to show evidence of at least five installations in satisfactory operation for at least five years.
   2. Each type of piping specialty and accessory shall be the product of one manufacturer.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Detailed drawings and data on each type of coupling, adaptor and expansion joint to be furnished. Submit and coordinate these with Shop Drawings required for piping systems. Comply with requirements of Section 01330, Submittals, and Section 01332, Shop Drawing Procedures.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Refer to Section 15051, Buried Piping Installation, and Section 15052, Exposed Piping Installation.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Couplings: Unless otherwise specified, piping 2-inches in diameter and larger passing from concrete to earth shall be provided with two pipe couplings or flexible joints as specified within 2-feet or one pipe diameter of the structure, whichever is greater.

1. Sleeve Type, Flexible Couplings:
   a. Pressure and Service: Same as connected piping.
   b. Material: Carbon steel for carbon steel and exposed ductile iron piping systems, or stainless steel for stainless steel and buried or submerged ductile iron piping systems.
   c. Gasket: Suitable for wastewater service, or high temperature air service.
   d. Bolts and Nuts: Alloy steel, corrosion-resistant, prime coated. Buried couplings shall have Type 316 stainless steel bolts and nuts.
   e. Harnessing:
      1) Harness couplings to restrain pressure piping. Test pressures for pressure pipelines shall conform to the requirements of Section 15050, Piping Systems.
      2) Adjacent flanges shall be tied with bolts of corrosion resistant alloy steel. Provide flange mounted stretcher bolt plates as shown on the Drawings and to be designed by manufacturer, unless otherwise approved by the ENGINEER.
      3) Conform to dimensions, size, spacing and materials for lugs, bolts, washers and nuts as recommended by manufacturer and approved by ENGINEER for the pipe size, wall thickness and test pressure required. However, the following minimum bolting shall be provided, unless otherwise approved by the ENGINEER.

Pipe Diameter (Inches)	Number of Bolts	Bolt Diameter (Inches)	At (Degrees)
4	2	5/8	180
6-8	2	3/4	180
10-12	2	7/8	180 or 250
14-20	4	1	190
24-48	4	1	90
54	4	1	250
60	4	1-1/4	90

   f. Remove pipe stop, unless otherwise shown on the Drawings or specified.
   g. As Manufactured by one of the following:
      1) Style 38, Dresser Industries.
      2) Type 411, Smith Blair.
      3) Type 501, Romac Industries
      4) Or equal.
2. Flanged Coupling Adapters:
   a. Description: One end of adapter shall be flanged and the other end shall have a sleeve type flexible coupling.
   b. Pressure and Service: Same as connected piping.
   c. Material: Cast iron or steel.

d. Gasket suitable for wastewater and digester gas service and can withstand the specified temperature. EPDM gaskets for 250°F air service.
e. Bolts and Nuts: Type 316 stainless steel.
f. Harnessing:
    1) Harness adapters to restrain pressure piping. Test pressures for pressure pipelines shall conform to the requirements of Section 15050, Piping Systems.
    2) For adapters 12-inch diameter and less, provide 1/2- inch minimum stainless steel anchor studs installed in a pressure tight anchor boss. Provide number of studs required to restrain test pressure and service conditions. Harness shall be as designed and recommended by manufacturer; however, the following minimum anchor studs shall be provided, unless otherwise approved by ENGINEER.
        a) 6-inch diameter and less: Two.
        b) 8-inch diameter and less: Four.
        c) 10-inch diameter and less: Six.
        d) 12-inch diameter and less: Eight.
    3) For adapters larger than 12-inch diameter, provide split-ring harness clamps with a minimum of four Type 316 stainless steel bolts. Harness assembly shall be as designed and recommended by manufacturer. Dimensions, sizes, spacings and materials shall be suitable for service and conditions encountered and shall be approved by ENGINEER.
    4) Harness couplings to restrain pressure piping.
    5) Test pressures for pressure pipe lines shall conform to the requirements of Section 15050, Piping Systems.
    6) Harnessing shall conform to the details shown on the Drawings.
g. As manufactured by one of the following:
    1) Type 911 or Type 913, Smith Blair.
    2) RFCA or Style FC 400, Romac Industries.
    3) Or equal.

3. Split Type Grooved or Shouldered End Flexible Couplings:
    a. Pressure and Service: Same as connected piping. Use shouldered end where required by pressure rating.
    b. Couplings shall conform to the applicable requirements of AWWA C606, Standard for Grooved and Shouldered Type Joints.
    c. Housing Material:
        1) For coupling of cast iron pipe, steel pipe, and plastic pipe: Malleable iron or ductile iron.
        2) For coupling of stainless steel pipe: Type 304 stainless steel, or equal.
    d. Gaskets: Suitable for wastewater service.
    e. Bolts and Nuts: Heat treated carbon steel track bolts, plated.
    f. As manufactured by one of the following:
        1) For coupling of ductile iron pipe:
            a) Victaulic Company.

b) Or equal.

2) For coupling of thermoplastic pipe:
   a) Victaulic Company.
   b) Or equal.

B. Rubber Type Expansion Joints:
   1. General:
      a. Use rubber type expansion joints at all expansion joint locations, except where stainless steel expansion joints are shown on the Drawings or specified.
   2. Liquid Service:
      a. Expansion joints for liquid service shall be constructed of Neoprene or Buna N suitable for temperatures to 180°F.
      b. Expansion joints shall be of the filled arch type. Furnish backup or retaining rings as recommended by the manufacturer.
      c. Expansion joints shall be yoked in a manner to provide for transmission of any tension loading to which the joint may be subjected during system operation. The compressive and/or lateral movement of the joint shall not be impaired by the yoking system. Details of expansion joint yoking shall be submitted to the ENGINEER for approval.

2.2 PAINTING

A. Clean and shop prime and shop finish coat ferrous metal surfaces of equipment in accordance with the requirements of Section 09900, Painting.

B. Coat machined, polished and non-ferrous surfaces and similar unpainted surfaces with corrosion prevention compound which shall be maintained during storage and until equipment begins operation.

C. Field painting shall conform to the requirements of Section 09900, Painting.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install piping specialties and accessories in accordance with manufacturer's instructions and recommendations.

B. Make adjustments to expansion joints as required to ensure that they will be fully extended when the ambient temperature is at minimum operating temperature and fully compressed at maximum operating temperature for the system in which they are installed.

+ + END OF SECTION + +

SECTION 15141

POTABLE WATER PIPING SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, material, equipment and incidentals as shown on the Drawings, specified and required to furnish and install a complete and workable system of potable water piping including all piping, valves, and accessories to the limits shown on the Drawings.

1.2 QUALITY ASSURANCE

A. Requirements of Regulatory Agencies:
   1. Building Codes: Comply with applicable requirements of all governing authorities and the following codes:
      a. Phoenix Plumbing Code.
      b. Uniform Standard Specification for Public Works Construction by the Maricopa Association of Governments (MAG), as supplemented by the City of Phoenix.
   2. Permits: Obtain and pay for all required permits, fees and inspections by authorities having jurisdiction.

B. Reference Standards: Comply with applicable provisions and recommendations of the following, except as otherwise shown or specified.
   1. ANSI A13.1, Identification of Piping Systems.
   2. ANSI B16.3, Malleable Iron Screwed Fittings, 150 and 300 lb.
   3. ANSI A21.4, Cement-Mortar Lining for Cast-Iron and ductile Cast-Iron Piping for Water and Other Liquids (AWWA C105).
   4. ANSI A21.10, Gray-Iron and Ductile-Iron Fittings, 2 in. through 48 in., for Water and Other Liquids (AWWA C110).
   5. ANSI A21.11, Rubber Gasket Joints for Cast-Iron and Ductile-Iron Pressure Pipe and Fittings (AWWA C111).
   6. ANSI A21.51, Ductile-Iron Pipe, Centrifugally Cast, in Metal Molds or Sand-Lined Molds, for Water or Other Liquids (AWWA C151).
   7. ANSI B16.1, Cast Iron Pipe Flanged Fittings, Class 25, 125, 150 and 800.
   8. ANSI B16.3, Malleable-Iron Screwed Fittings, 150 and 300 lb.
   9. ANSI B16.5, Steel Pipe Flanges, Flanged Valves, and Fittings.
   10. ANSI B16.15, Cast Bronze Threaded Fittings, 125 and 250 lbs.
   11. ANSI B16.18, Cast Bronze Solder Joint Pressure Fittings.
   12. ANSI B16.22, Wrought Copper and Bronze Solder-Joint Pressure Fittings.
   13. ANSI B16.24, Bronze Flanges and Flanged Fittings, 150 and 300 lbs.

14. ANSI B16.26, Cast Copper Alloy Fittings for Flared Copper Tubes.
15. ANSI B125.2, Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Pipe for Ordinary Uses, (ASTM A 120).
16. ANSI H 23.1, Seamless Copper Water Tube, (ASTM B 88).
17. ANSI H27.1, Seamless Red Brass Pipe, Standard Sizes (ASTM B 43).
18. ASTM A 53, Specification for Pipe, Steel, Black and Hot Dipped, Zinc Coated, Welded and Seamless Pipe.
19. ASTM A 183, Specification for Carbon Steel Track Bolts and Nuts.
20. ASTM A 307, Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
21. ASTM A 449, Specification for Quenched and Tempered Steel Bolts and Studs.
22. ASTM B 32, Specification for Solder Metal.
23. ASTM B 813, Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube.
24. ASTM D 1330, Specification for Rubber-Sheet Gaskets.
25. ASTM D 2000, Classification System for Rubber Products in Automotive Applications.
26. FS O-F-506B, Flux, Soldering: Paste and Liquid.
27. FS WW-U-531C, Unions, Pipe; Steel or Malleable Iron; Threaded Connection.
28. FS WW-U-516, Unions, Brass or Bronze; 250 pound.
29. PDI WH-201, Covering Certification, Sizing Placement and Reference Data for Water Hammer Arresters.

1.3 SYSTEM PERFORMANCE REQUIREMENTS

A. Provide components and installation capable of producing plumbing piping systems with the following minimum working pressure ratings, except where indicated otherwise:
   1. Water Distribution Systems, Below Ground: 50 psig.
   2. Water Distribution Systems, Above Ground: 50 psig.

1.4 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Manufacturers literature, specifications, and engineering data including dimensions, size and materials for the following:
      a. Pipe and Fittings.
      b. Valves.
      c. Backflow Preventers including assembly of parts lists.
      d. Strainers.
      e. Water Meters.
      f. Dielectric Couplings.
      g. Flexible connectors.
      h. Vacuum Breaker.
      i. Water Hammer Arresters.

j. Hose Bibbs and Couplings.
k. Thermometers.
l. Pressure Gages.
m. Pressure Reducing Valves.
n. Air Release Valves.
o. Service Sink.
p. Janitor's sink.
q. Other materials and equipment requested by ENGINEER.

2. Detailed 1/4-inch scale drawings showing materials and dimensions of the complete water piping systems, in plan and in section.
3. Guarantees.

B. Record Drawings: Provide as specified in Section 01782, Record Documents.

C. Operation and Maintenance Manuals:
1. Furnish Operation and Maintenance Manuals in conformance with the requirements of Section 01781, Operation and Maintenance Data.

1.5 JOB CONDITIONS

A. Protection: Properly plug or cap the open ends of all pipe at the end of each days Work or other stopping point throughout construction. Equipment shall be tightly covered and protected against dirt, water and chemical or mechanical injury.

B. All excavation and backfill required for underground piping installed under this Section shall conform to Section 15051, Buried Piping Installation.

C. Provide water meter rig and reduced pressure zone backflow preventer rig in accordance with requirements of local water company.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Copper Water Tube:
1. Tube:
a. Reference: ANSI H23.1, ASTM B88.
b. Type: K or L.
c. Temper: Hard-drawn or soft-annealed.
2. Fittings:
a. Reference: ANSI B16.22.
b. Reference: ANSI B16.26.
c. Reference: ANSI B16.18.

3. Joints:
    a. Sweat:
        1) Solder Metal: ASTM B 32.
        2) Flux: FS O-F-506, Type 1.
    b. Flanged:
        1) Flanges: ANSI B16.24, 150 lb. class.
        2) Gaskets: Red rubber, ASTM D1330, Grade 1, 1/8-inch thick.
        3) Nuts and Bolts: ASTM A 307.
4. Unions:
    a. Reference: FS WW-U-516.
    b. Material: Bronze.
    c. Rating: 250 pound W.O.G.

B. Ductile Iron Pipe:
1. Pipe: Ductile-Iron ANSI A21.51.
2. Fittings: Ductile-Iron ANSI A21.11.
3. Joints.
    a. Mechanical Joint (Underground):
        1) Glands, Bolts and Nuts: ANSI A21.11.
    b. Grooved Joints (Exposed):
        1) Reference: ANSI B16.1, Class 125 or Class 250, as required.
    c. Flanged Joints (Exposed):
        1) Reference: ANSI B16.1, Class 125 or Class 250, as required.
    d. Provide a flange by mechanical joint adapter at all underground connections.
4. Lining: Cement lined ANSI A21.4.

C. Dielectric Couplings:
1. Type: Union or flange.
2. Product and Manufacturer: Provide one of the following:
    a. Watts Regulator Co.
    b. Epco Sales Inc.
    c. Or equal.
3. Ratings:
    a. Unions: 250 psi, ANSI B16.39.
    b. Flanges: 175 psi, ANSI B16.42 (iron), ANSI B16.24 (Bronze).

2.2 VALVES

A. Bronze Body Globe Valves:
1. Type: Composition disc, union bonnet.
2. Materials: Brass and bronze.
3. Rating: 150 lb. SWP.
4. End Connections: Solder joint.
5. Product and Manufacturer: Provide one of the following:

a. Stockham Valves and Fittings, Fig. No. B-24.
b. Lunkenheimer Co., Fig. No. 126.
c. Or equal.

B. Bronze Body Check Valves:
1. Type: Swing, regrinding bronze disc, screw-in cap.
2. Materials: Brass and bronze.
3. Rating: 150 lb. SWP.
4. End Connections: Solder joint.
5. Product and Manufacturer: Provide one of the following:
a. Stockham Valves and Fittings, Fig. No. T-285.
b. Lunkenheimer Co., Fig. No. 2145.
c. Or equal.

C. Bronze Body Ball Valves:
1. Type: Non-blowout stem, adjustable packing gland, quarter turn, full port ball valve.
2. Materials:
a. Body: Cast bronze.
b. Ball: Chrome plated brass.
c. Packing and Seats: Teflon.
3. Rating: 150 lb. SWP.
4. End Connection: Screwed. Provide screwed to sweat adapters where required.
5. Product and Manufacturer: Provide one of the following:
a. Stockham Valves and Fittings, Fig. S-217 BR-R-T.
b. Lunkenheimer Co., Fig. 707-XLT.
c. Or equal.

D. Bronze Body Gate Valves:
1. Type: Rising stem, union bonnet solid wedge disc.
2. Materials: Brass and bronze.
3. Rating: 150 lb. SWP.
4. End Connections: Screwed.
5. Product and Manufacturer: Provide one of the following:
a. Stockham Valves and Fittings, Fig. No. B-124.
b. Lunkenheimer Co., Fig. No. 3155.
c. Or equal.

E. Strainers:
1. Type: Self-cleaning "Y" body with blow-off cock.
2. Construction:
a. Basket: Perforated stainless steel basket.
b. Perforations: 0.045-inches diameter, minimum.
c. Free Area: Four times cross sectional area of connecting pipe, minimum.
3. Strainers 2-1/2-inch and smaller:

a. Materials:
1) Body: Cast bronze.
2) ASTM B-62.
b. Pressure Rating: 250 psi steam at 425°F temperature.
c. End Connections: Solder ends or screwed ends with adapters for screw to sweat ends.
d. Blowoff Connection: Unplugged, NPT blowoff connection.

4. Strainers 3-Inches and Larger:
a. Construction:
1) Body: Cast iron ASTM A-126B.
b. Pressure Rating: 125 psi steam.
c. End Connections: Flanged ANSI B16.1 drilling.
d. Blowoff Connections: Tapped, NPT, unplugged.
5. Provide short nipple and blowoff valve for each strainer.
6. Product and Manufacturer: Provide one of the following:
a. Mueller Steam Specialty Co.
b. Armstrong Steam Specialty Co.
c. Or equal.

F. Iron Body Gate Valves:
1. Type: Rising stem, outside screw and yoke, solid wedge.
2. Materials: Iron with bronze trim.
3. Rating: 125 lb. SWP.
4. End Connections: Flanged, ANSI B16.1 drilling.
5. Provide chainwheel operators for all valves above 5-foot 6-inches above floor.
6. Product and Manufacturer: Provide one of the following:
a. Stockham Valves and Fittings, Fig. No. G-623.
b. Lunkenheimer Co., Fig. No. 1430.
c. Or equal.

G. Iron Body Check Valves:
1. Type: Swing, regrind-renew disc and seat ring, bolted cover.
2. Materials: Iron body, bronze trim, bronze disc and seat ring.
3. Rating: 125 lb. SWP.
4. End Connections: Flanged, ANSI B16.1 drilling.
5. Product and Manufacturer: Provide one of the following:
a. Stockham Valves and Fittings, Fig. No. G-931.
b. Lunkenheimer Co., Fig. No. 1790.
c. Or equal.

2.3 EQUIPMENT

A. Hose Bibbs, Pipe Drains:
1. Valve:
a. Type: Boiler drain globe valve, chrome plated.

b. Material: Bronze body, screwed bonnet, renewable composition disc.
c. End Connections: Hose thread outlet, male pipe thread or sweat inlet.
d. Rating: 125 lbs. WOG.

2. Vacuum Breaker:
a. Type: Non-removable, atmospheric.
b. Materials: Brass body, stainless steel trim, silicone rubber diaphragm and disc.
c. End Connections: Hose thread inlet and outlet.

3. Product and Manufacturer: Provide one of the following:
a. Woodford Manufacturing Co., Model 24C.
b. Nibco Inc., Fig. No. 74VB.
c. Or equal.

B. Wall Hydrants:
1. Box-Type Hose Connection, Non-Freeze Type:
a. Type: Anti-siphon non-freeze wall hydrant.
b. Materials:
1) Casing: Bronze with statuary bronze finish.
2) Vacuum Breaker: Integral.
3) Threads: Standard 3/4-inch hose thread outlet.
4) Wall Clamp: Adjustable with set screw.
5) Key: Removable tee handle type.
c. Connection: 3/4-inch sweat end inlet and 3/4-inch hose thread outlet, universal type.
d. Product and Manufacturer: Provide one of the following:
1) Jay R. Smith, Fig. No. 5609-SE.
2) Zurn Industries, Fig. No. Z-1300.
3) Or equal.

C. Water Hammer Arresters:
1. Materials:
a. Casing: Stainless steel.
b. Bellows: Stainless steel.
c. Bellows Contents: Nitrogen gas.
2. Connection: Male NPT thread.
3. Maximum Working Pressure: 250 psig.
4. Sizing and Certification: P.D.I. WH-201.
5. Product and Manufacturer: Provide one of the following:
a. Hydrotrol by Jay R. Smith Manufacturing Co.
b. Shoktrol by Zurn Industries.
c. Or equal.

D. Pipe Labels:
1. Type: Self-adhering, temperature resistant, waterproof, corrosion resistant.

2. Marker size, marker color, legend size, and legend color shall conform to ANSI A13.1.

E. Flexible Connections:
1. Type: Flexible connections for piping 2-1/2-inches and smaller.
2. Construction:
   a. Hose: Bronze.
   b. Braid: Bronze.
3. Pressure Ratings: 190 psig working pressure at 250°F temperature.
4. End Connections: Solder end welded to hose and braid ends.
5. Product and Manufacturer: Provide one of the following:
   a. Flexonics Inc.
   b. Anaconda Metal Hose Division, Anamet Incorporated.
   c. Or equal.

F. Automatic Air Vents:
1. Type: Automatic vent air eliminator with built-in air chamber.
2. Construction:
   a. Body: Bronze.
   b. Finish: Chrome plated exterior.
   c. Overflow Connector: Provide connection for 1/4-inch O.D. copper tubing.
3. Ratings: 75 psig working pressure.
4. Product and Manufacturer: Provide one of the following:
   a. Bell and Gossett.
   b. Armstrong Pump Co.
   c. Or equal.

G. Thermometers:
1. Range: 30°F to 240°F temperature range in maximum of 2°F increments.
2. Type: Adjustable Angle Column Type Thermometer.
   a. Construction:
      1) Scales and Lens: 9-inch high satin finish aluminum scales, black numerals, front red reading mercury tubes.
      2) Wells: Insertion well with brass separable sockets.
      3) Neck: 2-1/2-inch extension neck.
      4) Window: Glass or clear acrylic plastic.
3. Type: Direct mounted, adjustable angle, dial type thermometer.
   a. Construction:
      1) 4-1/2-inch diameter cast aluminum with black finish.
      2) Ring: Chrome plated close type.
      3) Dial: White face with black numerals and graduations.
      4) Window: Glass or clear acrylic plastic.
      5) Pointer: Stainless steel, black finish, red tip, adjustable.
      6) Wells: Insertion wells with brass separable socket.
      7) Neck: 1-1/2-inch extension neck.

8) Connection: Bottom connection.

4. Product and Manufacturer: Provide one of the following:
   a. Weksler Instrument Co.
   b. H.O. Trerice Co.
   c. Or equal.

H. Pressure Gages:
   1. Reference Division 17000, Specification 17052

I. Backflow Preventers: 1/2-Inch to 2-Inches:
   1. Type: Reduced pressure zone device with two independently acting check valves, together with an automatically operated pressure differential relief valve located between the two check valves.
   2. Materials:
      a. Body: Bronze.
      b. Valve Discs: EPT rubber.
      c. Diaphragm: Buna-N and nylon.
      d. Springs: Stainless steel.
      e. Screws: Stainless steel.
   3. Maximum Working Pressure: 150 psi.
   4. End Connection: Screwed.
   5. Accessories:
      a. Air gap drain funnel with threaded outlet and vent elbow furnished by manufacturer.
      b. Strainer with blowoff on inlet.
      c. Ball valves on inlet and outlet.
      d. Reduced pressure principle backflow preventer test kit for each unit furnished, provided in molded plastic carrying case with foam inserts.
   6. Product and Manufacturers: Provide one of the following:
      a. Conbraco Industries, Incorporated, Series 40-200.
      b. Hersey Products, Aergap Model FRP-II.
      c. Febco, Model 825Y.
      d. Watts Regulator Co., Series 909.
      e. Or equal.

J. Backflow Preventers: 2-1/2-Inches and Larger:
   1. Type: Reduced pressure zone device with two independently acting check valves, together with an automatically operated pressure differential relief valve located between the two check valves.
   2. Materials:
      a. Body: Bronze or cast iron.
      b. Valve Discs: Neoprene.
      c. Diaphragm: Neoprene coated cotton duck.
   3. Maximum Working Pressure: 175 psi.
   4. End Connections: Screwed or flanged.

5. Accessories:
   a. Air gap drain funnel with threaded outlet and vent below furnished by manufacturer.
   b. Strainer with blowoff on inlet.
   c. O.S. and Y gate valves on inlet and outlet.
   d. Reduced pressure principle backflow preventer test kit for each unit furnished with carrying case, provided in molded plastic carrying case with foam inserts.
6. Product and Manufacturer: Provide one of the following:
   a. Hersey Products, Model 6CM.
   b. Febco, Model 825.
   c. Watts Regulator Co., Series 909.
   d. Or equal.

K. Water Meter:
1. Type: Magnetic Drive, disk water meter.
2. Materials:
   a. Body: Bronze.
   b. Register: Brass.
   c. Gear Train: Self lubricating celcon plastic.
3. Maximum Working Pressure: 150 psi.
4. End Connection: Flanged.
5. Product and Manufacturers: Provide one of the following:
   a. Hersey Products Inc., Model MHD.
   b. Neptune Water Meter Co., Model T-10.
   c. Or equal.

L. Vacuum Breakers:
1. Pressure Type: PVB:
   a. Type: An assembly containing an independently operating internally loaded check valve and an independently operating loaded air inlet valve located on the discharge side of the check valve. The assembly shall also be equipped with test cocks and shut off valves on the inlet and outlet of the assembly.
   b. Materials:
      1) Hood: Stainless steel.
      2) Bonnet: Bronze.
      3) Vent Disc: Silicone rubber.
      4) Disc Holder Float: Polyethylene.
      5) Check Valve Disc: Silicone rubber.
      6) Check Valve Seat: Bronze.
      7) Body: Bronze.
   c. Accessories:
      1) Ball valves on inlet and outlet.
      2) Ball valve test cocks.

d. Reference: ASSE Standard No. 1020.
e. Working Pressure: 150 psi.
f. Installation: Vertical, minimum 12-inches above fixture vacuum breaker serves.
g. Product and Manufacturer: Provide one of the following:
1) Watts Regulator Co., No. 800.
2) Conbraco Industries Inc., Series 40-500.
3) Febco, Model 765.
4) Or equal.

2. Atmospheric Type: AVB:
a. Type: An assembly containing an air inlet valve, a check seat and an air inlet port to prevent reverse flow of water and allow air into the water line to break a siphon.
b. Materials:
1) Hood: Bronze.
2) Body: Bronze.
3) Vent Disc: Silicone.
4) Disc Holder Float: Polyethylene.
5) Body: Bronze.
c. Reference: ASSE Standard No. 1001.
d. Working Pressure: 125 psi.
e. Installation: Vertical, minimum 6-inches above fixture vacuum breaker serves.
f. Product and Manufacturer: Provide one of the following:
1) Watts Regulator Co., No. 288A.
2) Conbraco Industries Inc., Series 38.
3) Febco, Model 710/715 as required.
4) Or equal.

M. Emergency Shower and Eyewash Stations:
1. Emergency Shower (Laboratory): ES:LAB:
a. Materials:
1) Shower Head: Polished chrome plated brass flush to ceiling.
2) Valve: Ball type, stay open with chrome plated, stainless steel rigid pull rod with handle length as required for ceiling height.
3) Supply: 1-inch IPS horizontal.
4) Ceiling Support: Provide hanger anchored to concrete deck above for support at elbow.
b. Product and Manufacturer: Provide one of the following:
1) Haws Drinking Faucet Co., Model 8169.
2) Speakman Co., Model SE-236-PR.
3) Or equal.
2. Eye Wash (Laboratory): EW:LAB:
a. Materials:
1) Heads: Twin chrome plated brass, soft flow.

2) Swivel Joint: Chrome plated.
3) Valve: Stay-open chrome plated ball valve, push type.
4) Exposed piping, chrome plated.

b. Product and Manufacturer: Provide one of the following:
1) Haws Drinking Faucet Co., Model 7612.
2) Speakman Co., Model SE-571.
3) Or equal.

3. Emergency Shower and Eyewash (Corrosion Resistant): ESE-1:
a. Type: Free standing corrosion resistant emergency shower and eyewash station.
b. Materials:
1) Shower: 9-inch diameter cycolac plastic shower head with 1-1/2-inch stay-open stainless steel ball valve and 24-inch rigid pull rod.
2) Eye/Face-Wash: Cycolac bowl with twin Buna-N covered ABS heads and stainless steel ball valve, stay open type.
3) Pipe: All PVC parts shall be Schedule 80, painted safety yellow.
4) Supply: 1-1/4 inch PVC.
c. As Manufactured by one of the following:
1) Haws.
2) Speakman Co.
3) Or equal.

4. Flow Switches, Audible and Visible Alarms:
a. Type: Single pole, double throw, NEMA 4X, UL listed paddle type flow switch. Contacts to be rated for 5 amps at 120 volts.
b. Flow switches shall be furnished by emergency shower and eyewash manufacturer at each shower and/or eyewash station. Shower flow switch shall be rated for 25 to 30 gpm flow and eyewash flow switch shall be rated for 0.3 to 3 gpm flow.
c. Flow switches shall sense flow for showers and eyewashes. Flow switches shall be full line size so as not restrict water flow in order to detect flow. Provide separate flow switch for shower and eyewash, as required at each emergency shower and eyewash station.
d. Visible alarm shall be an amber flashing light, NEMA 4X, UL listed.
e. Audible alarm shall be an intermittent signal rated at 85 db at ten feet, NEMA 4X.
f. Each emergency shower station shall be furnished with a shower and eyewash test kit.
g. Product and Manufacturer: Provide one of the following:
1) Haws Drinking Faucet Co. Model 9001.
2) Speakman Co., Model AL-2-FLW (FS6W).
3) Or equal.

5. Safety Valve Lockout with Padlock:
a. Heavy duty plastic, dielectric and chemical resistant valve lock.
b. Padlock with unique serial number, hardened steel shackle, two brass keys with matching serial numbers for each padlock.

c. Product and Manufacturer: Provide one of the following:
   1) Akron, Safety Products, Inc.
   2) Brady USA, Inc.
   3) Or equal.

6. Anti-Scald Valves:
   a. Anti-scald valve provides scald protection and bleeds valve whenever internal temperature rises above 100°F and closes when line temperature drops to 85°F.
   b. Product and Manufacturer: Provide one of the following:
      1) Haws Drinking Faucet Co., Model SP157A scald-protection valve.
      2) Speakman Co.
      3) Or equal.

N. Aquastats:
   1. Type: Immersion type for regulating water temperature in hot water piping, tempered water piping, or hot water storage tanks.
   2. Electrical Rating: 120 volts.
   3. Setpoint Range:
      a. Domestic Hot Water: Make contacts on temperature drop below 112°F, break contacts on temperature rise above 120°F.
      b. Tempered Water: Make contacts on temperature drop below 65°F, break contacts on temperature rise above 73°F.
   4. Adjustment: Adjustable setpoint through knob on cover.
   5. Differential: Adjustable 3°F to 10°F.
   6. Accessories: Provide immersion well.
   7. Product and Manufacturer: Provide one of the following:
      a. Honeywell.
      b. Johnson Controls.
      c. Or equal.

O. Hot Water Temperature Maintenance Heat Tracing System:
   1. General: Furnish and install a complete UL Listed system of heaters and components approved and designed specifically for maintaining hot water temperature of 120°F. Hot water lines from hot water heater(s) to plumbing fixtures and as shown on Drawings, shall be electrically traced with self limiting heaters. Manufacturer shall assist in selecting the correct tracer and develop bill of materials. All connections and equipment shall be moisture-proof.
   2. The heater cable assembly shall consist of two 14 A.G. parallel nickel-plated copper bus wires imbedded in a self regulating core and covered in a cross-linked polyolefin insulating jacket. The heater assembly shall be covered with tinned copper metallic braid and an outer jacket of cross-linked polyolefin insulation, nominally of 40 mil thickness, and color coded for easy identification.
   3. The cable shall be rated for 208 volt operation.

4. Pipe and heat trace shall be insulated as specified in Section 15082, Insulation of Piping and Equipment - HVAC and Process Air.
5. Provide all splice power-to-tracing connectors, thermostats, end terminations, straps, ground fault circuit breakers, junction boxes, etc as required.
6. Product and Manufacturer: Provide one of the following:
   a. Thermon Manufacturing Co., Type HSX 2100.
   b. Or equal.

P. Hose Reels:
1. Type: Continuous flow hose reel.
2. Materials:
   a. Rims: Tubular steel, welded.
   b. Spokes: 3/8-inch diameter steel rods.
   c. Frame: Heavy steel bar frame.
   d. Drum: Galvanized steel.
   e. Finish: Baked enamel.
3. Connections: 1-inch inlet and outlet.
4. Threads: 1-inch N.S.T.
5. Product and Manufacturer: Provide one of the following:
   a. Crocker-Standard, Fig. No. 7025.
   b. Potter Roemer Inc., Fig. No. 2838.
   c. Or equal.

Q. Hose Nozzles:
1. Materials:
   a. Body: Lexan.
   b. Stem: Brass.
   c. Bumper: Rubber.
2. Threads: 1-inch N.S.T.
3. Nozzle: Adjustable fog nozzle, capable of complete shut-off, solid straight stream, or any degree of solid conical fog.
4. Product and Manufacturer: Provide one of the following:
   a. Crocker-Standard, Fig. No. 3477.
   b. Potter Roemer Inc., Fig. No. 2959.
   c. Or equal.

R. Hose:
1. Type: Double braided synthetic hose for use with continuous flow reels to permit flow while hose is coiled on reel. Couplings shall connect to hose nozzle threads and male hose outlet threads on hose reel.
2. Threads: 1-inch N.S.T.
3. Hose Size: 1-inch.
4. Length: One continuous length as shown on Drawings with no intermediate couplings.
5. Product and Manufacturer: Provide one of the following:

a. Croker-Standard, Fig. No. 7037 with brass coupling for non-collapsible hose.
b. Potter Roemer, Fig. No. 2852 hose with Fig. No. 2862 coupling.
c. Or equal.

S. Quick Coupler Connections:
1. Type: Cam arms lock into adaptor groove.
2. Materials: Adaptor and Coupler:
a. Body: Stainless steel.
b. Cam arms: Stainless steel.
c. Gaskets: Buna N.
3. Ends: Socket weld quick connect adaptor for connection to copper tubing; hose shank quick connect coupler.
4. Reference: MIL-C-27487.
5. Product and Manufacturer: Provide one of the following:
a. Dover Corp., OPW "Kamlok" 633 series.
b. Or equal.

T. Trap Primer Valve:
1. Construction:
a. Body: Brass.
b. Seals: O-ring 40°F to 450°F.
c. Inlet and Outlet Size: 1/2-inch.
d. Integral backflow preventer.
e. Provide multiple outlet distribution unit, as required.
f. Reference: ASSE Standard No. 1018.
g. Accessories: Floor drain trap primer distribution unit.
2. Product and Manufacturer: Provide one of the following:
a. Precision Plumbing Products.
b. Or equal.

U. Trap Primer Valve:
1. Type: Automatic trap priming assembly with timer, solenoid valve and air-gap device to automatically prime traps at set time intervals regardless of trap primer device location.
2. Description: An electronically activated trap priming device. Primer functions at a pre-selected time, delivering water across an air gap funnel.
3. Construction:
a. Body: Brass.
b. Seals: O-ring 40°F to 450°F.
c. Inlet and Outlet Size: 1/2-inch.
d. Air gap device.
e. Solenoid valve 115VAC, 6.3 watts, 60 Hz, Normally Closed.
e. Provide multiple outlet distribution unit as required.
f. Reference: ANSI/ASME A112.1.2 Air Gap in Plumbing Systems Standard.

g. Accessories: Floor drain trap primer distribution unit, a timer set to operate for six seconds every 24 hours.

4. Product and Manufacturer: Provide one of the following:
   a. Precision Plumbing Products, Solo-Prime Electronic Trap Priming Assembly Model SP-500-115V.
   b. Or equal.

2.4 MATERIAL SELECTION

A. All potable water supply, hot, and cold piping 2-1/2-inches and smaller, run within the interior of a building, shall be hard-drawn copper Type "L" with solder joints and connections.

B. All potable water piping 2-1/2-inches and smaller run underground shall be soft-annealed copper Type "K" copper tubing.

C. All underground water piping 3-inches and larger shall be cement-lined ductile iron pipe with mechanical joints.

D. All water piping 3-inches and larger run within the interior of a building, shall be cement-lined ductile iron pipe with flanged or grooved joints.

E. All exposed water piping and valves to plumbing fixtures shall be chrome plated brass.

F. All valves for copper piping shall be bronze bodied, unless otherwise specified.

G. All valves for ductile iron piping shall be iron bodied, unless otherwise specified.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation of piping shall be in accordance with Section 15143, Installation of Plumbing Piping.

B. All piping shall be pitched to facilitate draining. Drain valves shall be provided at system low points.

C. Harnessed flexible couplings or pipe loops shall be provided on all piping subject to thermal expansion and where piping 3-inches and larger crosses building expansion joints.

D. Unions shall be provided for all screwed piping at connections to equipment and at convenient locations to permit disassembly of piping.

E. All connections between ferrous and non-ferrous piping materials shall be made with dielectric couplings.

F. Care shall be taken so as not to leave tool marks or abrasions on plated, polished or soft metal piping.

G. Wherever changes in sizes of piping occur, changes shall be made with reducing fittings. The use of bushings is not permitted, unless otherwise shown on the Drawings.

H. All exposed unfurred pipes, whether insulated or not, shall be identified with pipe labels and the direction of flow indicated. Labels may be omitted from piping where the use is obvious, due to its connection to fixtures and where the appearance would be objectionable in finished rooms; as approved by the ENGINEER. Identification labels shall be placed as follows:
   1. Near each valve and branch connection.
   2. Wherever piping emerges or disappears from view, when viewed from the floor of the room in which it is installed.
   3. At not more than 25-foot intervals.

I. All pipes passing through ceilings, floors and walls in finished rooms, and all supplies to fixtures shall have escutcheon plates.

J. All thermometers shall be legible from a standing position on the floor.

K. Pressure gage ranges shall be selected for proper sensitivity, so that the dial indicator points to the approximate center of the dial in normal operation.

L. Provide automatic air vents at high points of hot water lines and where shown on the Drawings.

M. Provide valved blow-off connections for each strainer.

N. Remove each fine mesh start-up strainer screen and replace with final stainless steel strainer screen after 30 days of operating time.

O. Conform to applicable requirements in Section 15143, Installation of Plumbing Piping.

P. Provide shutoff valves to each piece of equipment furnished.

Q. Every section of branch supply and return piping and all risers of all services shall be controlled by a valve at the main.

3.2 PREPARATION

A. Disinfection: Conform to Section 15142, Disinfection, Plumbing.

3.3 FIELD QUALITY CONTROL

A. Tests: Pressure test all systems in conformance with Section 15050, Piping Systems, and Section 15144, Testing of Plumbing Piping Systems.

3.4 CLEANING

A. Remove all debris, dirt and waste materials resulting from installation.

B. Remove dirt, dust, rust, etc. from piping in preparation for painting, testing and insulating.

C. Clean lenses on thermometers, pressure gauges, etc. where required.

+ + END OF SECTION + +

SECTION 15142

DISINFECTION, PLUMBING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Responsibility belongs to CONTRACTOR for the proper disinfection of all potable water lines with compliance to codes and regulations, as specified.

1.2 QUALITY ASSURANCE

A. Requirements of Regulatory Agencies: Comply with the applicable provisions of regulatory agencies below and others having jurisdiction.
   1. Building Codes: Comply with applicable requirements of all governing authorities and the following codes:
      a. Phoenix Building Code.
      b. Phoenix Plumbing Code.
   2. Permits: Obtain and pay for all required permits, fees and inspections by authorities having jurisdiction.

B. Reference Standards: Comply with applicable provisions and recommendations of the following, except as otherwise shown or specified:
   1. AWWA C651 - Standard for Disinfecting Water Mains.
   2. AWWA C652 – Standard for Disinfection of Water-Storage Facilities
   3. AWWA C653 – Standard for Disinfection of Water Treatment Plants
   4. AWWA C654 – Standard for Disinfection of Wells

C. Testing: Bacteriological tests, as specified below, will be provided by the OWNER.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Description of the forms of chlorine, dosages and proposed methods of application.

PART 2 - PRODUCTS

2.1 GENERAL

A. Provide all necessary equipment and materials, including chemicals, to perform the disinfecting operations.

PART 3 - EXECUTION

3.1 DISINFECTION

A. General: All potable water pipelines shall be disinfected in accordance with MAG requirements and ANSI/AWWA C651 – Disinfecting Water Mains as modified herein.

B. Prior to disinfecting pipelines for potable water service and before placing into service, flush the pipeline to remove any debris, rocks and foreign material. Flushing shall be completed with velocities that exceed 2.5 ft/s. CONTRACTOR shall provide all tools, labor and equipment to complete flushing. OWNER shall provide water for flushing.

C. Continuous Feed Disinfection: Disinfect in accordance with ANSI/AWWA C651 except the following:

D. The water in the pipe shall contain 50mg/L of free chlorine.

E. After 24 hours of disinfection the residual free chlorine shall be at least 25 mg/L at pipelines extremities.

F. Valve Operation During Disinfection: During the disinfection of pipelines all valves and accessories shall be operated.

G. Final Flushing: After the applicable retention period the heavily chlorinated water shall be flushed from the pipeline until chlorine measurements show that the concentration is not higher than the typical free chlorine as determined by the OWNER.

+ + END OF SECTION + +

SECTION 15144

TESTING OF PLUMBING PIPING SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all tests necessary to demonstrate compliance with the Contract Documents, codes and regulations, which include water tests, air tests, and smoke tests as specified.

B. Coordination:
   1. Review installation procedures under other Sections and coordinate with the Work which is related to this Section including buried piping installation, and exposed piping installation.

1.2 QUALITY ASSURANCE

A. Requirements of Regulatory Agencies:
   1. Building Codes: Comply with applicable requirements of all governing authorities and the following codes:
      a. Phoenix Building Code.
      b. Phoenix Plumbing Code.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Description of proposed testing methods, procedures, and apparatus to the ENGINEER for approval at least 48 hours in advance of testing.
   2. Submit a test report for each test to the ENGINEER certifying the test pressure, duration of the test, and test performance of all installed piping.
   3. Valve Charts:
      a. Two required, 1/8-inch sheet acrylic in 8-1/2 by 11-inch extruded aluminum frame.
      b. Charts: Typed or inked on mylar with the following information for each valve.
         1) Valve identification number.
         2) Valve location.
         3) Valve use.
         4) Valve size.
         5) Manufacturer's name and model number.
      c. Submit sample valve chart with lettering.

PART 2 - PRODUCTS

2.1 GENERAL

A. Provide all necessary equipment and materials, including gages and pumps, to perform the testing operations.

2.2 CMMS TAGS

A. Refer to Section 01630, Computerized Maintenance Management System Tags for guidance.

B. Legend:
   1. P.W. - Potable Water.

PART 3 - EXECUTION

3.1 GENERAL

A. Conduct water, air and smoke tests as required on all piping systems, as specified below and conforming to the requirements of Section 15050, Piping Systems.

B. Conduct all tests in the presence of and in a manner approved by ENGINEER and the OWNER. Repeat test for the OWNER and ENGINEER, if requested.

C. Repair and retest all lines which do not pass the tests as specified herein.

D. Inspect all valves, joints, and specialties for tightness and for proper operation while under test pressure.

3.2 WATER TEST

A. Drainage and Vent System Piping:
   1. Perform tests either on the entire system or on successive sections of the system.
   2. Tightly close all openings, except the highest opening, of the system or section to be tested.
   3. Fill the system or section with water to the point of overflow.
   4. Test with a head of at least ten feet of water, except for the uppermost ten feet of the system.
   5. Allow water to stand in the system for at least 15 minutes before inspecting.
   6. Inspect the system or section for leaks and repair any leaks found.

B. Water Piping:
   1. Water piping shall be tested and proved tight under a pressure not less than 100 psi.
   2. Potable water shall be used for testing potable water systems.

3.3 AIR TEST

A. Attach air compressor testing apparatus to any suitable opening after closing all other inlets and outlets. Force dehydrated, oil-less, compressed, dew point - 40°F, air into system until there is a uniform gage pressure without the introduction of additional air. Below is a list of required gage pressures:
   1. Drainage and Vent Piping (substitute for water test) five psi for 15 minutes.
   2. Compressed Air Piping:
      a. Compressed air shall be tested at 150 psig for one hour. Duration time period to be measured after stabilization of the testing medium.
      b. All joints, fittings valves and other potential leak sources shall be swabbed with a leak detecting solution.
      c. A calibrated pressure gauge having maximum increments of two psi shall be used.
      d. Only temporary weld-end dished-head caps or threaded-end caps, swell plugs or compression end caps (maximum 2-inch) shall be installed during pressure test operations.
      e. No compression couplings larger than 2-inches shall be included in the pressure test inside buildings unless they are adequately blocked or anchored to prevent pull-out from thrust forces. All piping shall be securely anchored or blocked to prevent movement or blowouts.
      f. Do not include meter, regulator and final service tee at main in leakage test. This equipment shall be leak tested at service line pressure.

3.4 SMOKE TEST

A. Finished Plumbing: Final test for gas and water tightness of the completed drainage and vent system:
   1. Fill all traps with water.
   2. Introduce a pungent thick smoke, produced by one or more smoke machines, into the system.
   3. When the smoke appears at stack openings on the roof, close the system.
   4. Maintain a pressure in the system equivalent to a 1-inch water column for the period of the inspection.
   5. Inspect the system for leaks and repair any leaks found.

+ + END OF SECTION + +

SECTION 15145

PIPE SLEEVES - PLUMBING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish and install all pipe sleeves, other wall pieces and escutcheons to the limits shown on the Drawings.

B. Coordination:
   1. Review installation procedures under other Sections and coordinate with the Work, which is related to this Section.

1.2 QUALITY ASSURANCE

A. Reference Standards: Comply with applicable provisions and recommendations of the following, except as otherwise shown or specified.
   1. AWWA C100, Cast-Iron Pressure Fittings.
   2. AWWA C104 (ANSI A21.4), Cement-Mortar Lining for Cast-Iron and Ductile-Iron Pipe and Fittings for Water.
   3. AWWA C106 (ANSI A21.6), Cast-Iron Pipe Centrifugally Cast in Metal Molds, for Water or Other Liquids.
   4. AWWA C110 (ANSI A21.10), Gray-Iron and Ductile-Iron Fittings, 2 in. through 48 in., for Water and Other Liquids.
   5. AWWA C111 (ANSI A21.11) Rubber Gasket Joints for Cast-Iron and Ductile-Iron Pressure Pipe and Fittings.
   6. AWWA C115 (ANSI A21.15), Flanged Cast-Iron and Ductile-Iron Pipe with Threaded Flanges.
   7. AWWA C151 (ANSI A21.51), Ductile-Iron Pipe, Centrifugally Cast in Metal Molds or Sand-Lined Molds, for Water or Other Liquids.
   8. ANSI B16.1, Cast-Iron Pipe Flanges and Flanged Fittings.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Detailed drawings and data on all wall and floor pipe, pipe sleeves and mechanical seals. Submit and coordinate these with Shop Drawings required for all piping systems.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Pipe Sleeves:
   1. Ferrous and Plastic Pipe: Use standard weight galvanized steel pipe, unless otherwise shown on the Drawings.
   2. Copper Pipe: Use standard weight galvanized steel pipe with mechanical link seals as spacers, unless otherwise shown on the Drawings.
   3. Size sleeves to provide annular space required to accommodate mechanical link.

B. Cast Wall Sleeves:
   1. Material: Cast iron furnished with integral wall collar.
   2. Dimensions: As required for mechanical joint to pass through sleeve. Length as required.

C. Link Seals: Provide link type mechanical seals with adjusting bolts suitable for 20 psi working pressure where shown on the Drawings or required.
   1. Materials: Mechanical seals through non-fire rated walls or floors:
      a. Pressure Plate: Glass reinforced nylon plastic.
      b. Bolt and Nut: 18-8 stainless steel.
      c. Sealing Element: EPDM rubber.
   2. Materials: Mechanical seals through fire rated walls or floors; two independent mechanical seal assemblies required for each penetration:
      a. Pressure Plate: Low carbon steel, zinc galvanized plated.
      b. Bolt and Nut: Low carbon steel zinc galvanized.
      c. Sealing Element: Silicone rubber.
      d. Three-hour fire rating.
   3. Product and Manufacturer: Provide one of the following:
      a. Thunderline Corporation.
      b. Calpico, Incorporated.
      c. Or equal.

D. Wall, Floor and Ceiling Escutcheon Plates:
   1. Bare pipes passing through walls, floors and ceilings in any room: Provide escutcheon plates of cast brass or stamped steel, chrome plated, hinged with setscrews.
   2. Insulated pipes passing through walls, floors and ceilings in finished rooms: Provide plated escutcheon plates of stamped steel or cast brass, chrome plated, hinged with setscrews.
   3. Product and Manufacturer: Provide one of the following:
      a. Bridgeport Plumbing Products, Incorporated.
      b. Pegasus Manufacturing Incorporated.
      c. Or equal.

E. Exterior Walls or Floors: Below grade:
   1. Type: Thermoplastic sleeve for use in new construction where sleeves are exposed to liquid or on exterior walls or floors exposed to backfill only.
   2. Integral reinforcing ribs, anchor and waterstop collar textured surface for adhesion to concrete.
   3. Buried pipe sleeves shall have mechanical seals at each end.
   4. Product and Manufacturer: Provide one of the following:
      a. Thunderline Corporation.
      b. Calpico, Incorporated.
      c. Or equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Pipe Sleeves:
   1. Use sleeves wherever pipes pass through walls, partitions, floors and roofs, unless otherwise shown on the Drawings.
   2. All sleeves through floor slabs in finished areas shall extend a maximum of 1/4-inch above finished floor.
   3. Anchor sleeves to concrete and masonry walls as shown on the Drawings or otherwise approved by ENGINEER.
   4. Sleeves through walls shall be flush with wall face.
   5. Caulk and seal annular space between pipe and sleeve.
   6. All pipe joints and annular spaces in exterior walls or walls subjected to hydrostatic pressure shall be completely watertight.
   7. All vertical pipes through sleeves shall be installed with Link Seal "Pyro-Pacs" to maintain three-hour fire rating between the two fire areas.
   8. Size Sleeves to provide annular space as recommended by the mechanical seal manufacturer and as follows:

Pipe Size (Inches)	Sleeve ID Minus Pipe or Insulation OD (Inches)
Less than 2	1/2 to 3/4
2 to 4	3/4 to 1-1/4
6 to 12	1-1/4 to 2

   9. For mechanical link seals, size sleeves to provide space required to suit link type seals provided.
   10. Seal annular spaces between pipe and sleeve, material and installation shall be as specified in Section 07920, Caulking and Sealants.
   11. Do not install sleeves and pipes through structural members, unless specifically required due to coordination or obstructions, each sleeve condition shall be submitted for approval.

12. Buried pipe sleeves shall have mechanical seals at each end.

+ + END OF SECTION + +

SECTION 15146

PIPE HANGERS, SUPPORTS AND RESTRAINTS - PLUMBING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, material, equipment and incidentals as shown on the Drawings, specified and required to design, furnish and install an adequate system of support, guidance and anchorage for all piping systems specified under Division 15, applicable plumbing sections regarding piping.

B. Coordination:
   1. Review installation procedures within other Sections and coordinate the Work that must be installed with or attached to the hangers and supports.
   2. Responsibility belongs to CONTRACTOR to coordinate the location and placement of any necessary concrete inserts, and any cutting or drilling of structural members required with the Work of Division 3, Concrete, and Division 5, Metals.

1.2 QUALITY ASSURANCE

A. Design Criteria: The manufacturer shall conform to the following criteria:
   1. Designs generally accepted as exemplifying good engineering practice, using stock or production parts, shall be utilized wherever possible.
   2. Accurate weight balance calculations shall be made to determine the required supporting force at each hanger location and the pipe weight load at each equipment concentration.
   3. Pipe hangers shall be capable of supporting the pipe in all conditions of operation. They shall allow free expansion and contraction of the piping, and prevent excessive stress resulting from transferred weight being induced into the pipe or connected equipment.
   4. Hangers shall be designed so that they cannot become disengaged by movements of the supported pipe.

B. Requirements of Regulatory Agencies:
   1. Certifying Agencies: All hangers, supports, and inserts shall be as approved by Underwriters' Laboratories, Inc.

C. Reference Standards: Comply with applicable provisions and recommendations of the following except as otherwise shown or specified.
   1. ANSI B1.1, Unified Inch Screw Threads.
   2. FS WW-H-171c(1), Hangers and Supports, Pipe.

3. ASTM A36, Specification for Carbon Structural Steel.
4. ASTM A47, Specification for Ferritic Malleable Iron Castings.
5. ASTM A307, Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
6. ASTM A575, Specification for Steel Bars, Carbon, Merchant Quality, M-Grades.
7. ASTM A668, Specification for Steel Forgings, Carbon and Alloy, for General Industrial Use.
8. MSS SP-58, Pipe Hangers and Supports - Materials, Design and Manufacture.
9. MSS SP-69, Pipe Hangers and Supports - Selection and Application.
10. Phoenix Building Code.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. All hangers, inserts and supports for piping system specified.
   2. Location, installation, material, loads or forces, and deflection of all hangers and supports.
   3. Manufacturer's catalogs, literature, and engineering data on all hangers and supports.
   4. Load ratings, materials and installation shall be consistent with the recommendations of the MSS SP-58 and MSS SP-69 and Federal Specification WW-H-171 latest edition.
   5. Deviations from Contract Documents.

1.4 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Delivery of Materials: All materials shall be inspected for size, quality, and quantity against approved Shop Drawings.

B. Storage of Materials: All materials shall be packaged, labeled, and stored in a covered dry location until time of installation.

PART 2 -PRODUCTS

2.1 GENERAL

A. Components of hangers and supports shall conform to the following:
   1. Materials:
      a. Bolts: ASTM A 307, Grade A, unless otherwise specified below.
      b. Forgings: ASTM A 668.
      c. Malleable Iron: ASTM A 47.
      d. Rods and Bars: ASTM A 575.
      e. Threads: Unified Screw Threads, Class 2A and 2B, ANSI B1.1.
      f. Structural Steel: ASTM A 36.

2. Finish:
   a. Steel or Malleable Iron Items: Galvanized, unless otherwise specified or shown on the Drawings.
   b. Steel or malleable iron materials used for the support of uninsulated copper piping: Copper plated.
   c. Framing members and fittings: Dip painted with corrosion resisting primer as specified in Section 09900, Painting.
   d. All hangers, rods, bolts, nuts, inserts, washers located in the corrosive areas shall be Type 316 stainless steel.

B. Pipe Attachments: The following types of pipe attachments shall be considered acceptable:
   1. Adjustable Steel Clevis: FS WW-H-171E, Type 1.
   2. Steel Double Bolt Pipe Clamp: FS WW-H-171E, Type 3.
   3. Steel Pipe Clamp: FS WW-H-171E, Type 4.
   4. Adjustable Swivel Pipe Ring: FS WW-H-171E, Type 6.
   5. Adjustable Steel Band Hanger: FS WW-H-171E, Type 7.
   6. Riser Clamp: FS WW-H-171E, Type 8.
   7. Light Duty Cleves Hanger: FS WW-H-171E, Type 12.
   8. Long Clips: FS WW-H-171E, Type 26.
   9. Offset J-Hooks: FS WW-H-171E, Type 27.
   10. Steel Pipe Covering Protection Saddle: FS WW-H-171E, Type 40A.
   11. Insulation Protection Shield: FS WW-H-171E, Type 41.
   12. Pipe Saddle Support: FS WW-H-171E, Type 37.
   13. Pipe Stanchion Saddle: FS WW-H-171E, Type 38.
   14. Pipe Saddle Support with base: FS WW-H-171E, Type 36.
   15. Adjustable Roller Hanger: FS WW-H-171E, Type 42.

C. Structural Attachments: The following types of structural attachments shall be considered acceptable:
   1. Side Beam Clamp: FS WW-H-171E, Type 20.
   2. Center I-Beam Clamp: FS WW-H-171E, Type 21.
   3. Welded Steel Bracket: FS WW-H-171E, Types 32 and 33.
   4. Side Beam Bracket: FS WW-H-171E, Type 35.
   5. Malleable Iron with Galvanized Finish Concrete Insert: FS WW-H-171E, Type 18. The use of steel concrete inserts is prohibited and NOT acceptable.

D. Hanger Rod Attachments: Use as required to complete assembly:
   1. Forged Steel Cleves: FS WW-H-171E, Type 14.
   2. Adjustable Turnbuckle: FS WW-H-171E, Type 15.
   3. Forged Steel Welders Eye Nut: FS WW-H-171E, Type 17.

E. Expansion Joints:
   1. 2-1/2-inch and Smaller Copper Tubing:
      a. Construction: Two-ply phosphor bronze seamless bellows.

b. Shrouds: Brass protective shrouds.
c. End Connections: Male and female solder end fittings or screwed ends with adaptors for screwed to sweat ends.

2. 3-inch and Larger:
   a. Construction: Free flexing expansion joints with stainless steel corrugated members.
   b. End Connections: Welded ends with flanges.
3. Product and Manufacturer: Provide one of the following:
   a. Flexonics Division, Universal Oil Products Company.
   b. Anaconda Metal Hose Division, Anaconda American Brass Company.

F. Alignment Guides:
1. Type: Semi-steel spider with four guiding fingers and guiding cylinder with base.
2. Products and Manufacturer: Provide one of the following:
   a. Flexonics Division, Universal Oil Products Company.
   b. Anaconda Metal Hose Division, Anaconda American Brass Company.
   c. Or equal.

G. Connection Bolts: Materials shall be as specified in other Sections of the Specifications, or shown on the Drawings. Where materials are not specified or shown on the Drawings, they shall be of Type 316 stainless steel with Monel nuts.

H. Toggle Bolts:
1. Provide zinc plated spring wing toggle bolts of the size required for secure anchorage of individual items, but not less than 1/4-inch diameter, of length required.
2. Product and Manufacturer: Provide one of the following:
   a. Spring Wing Toggle Bolts by Ramset Fastening Systems.
   b. Rawl Toggle Bolts, Spring Wing Type.
   c. Or equal.

I. Furnish and install all necessary supports, angle iron stands, miscellaneous steel, inserts, anchor bolts and hangers required for all equipment furnished under this Contract, unless otherwise shown on the Drawings. All supports shall meet the requirements of the applicable Items of Division 5, Metals.

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PART 3 - EXECUTION

3.1 GENERAL

A. Insulated pipes with vapor barrier shall have an insulation protection shield conforming to FS WW-H-171E, Type 41 tack-welded to hanger.

B. Insulated pipes without vapor barrier shall have a steel protection saddle conforming to FS WW-H-171E, Type 40A tack-welded to hanger.

C. All ferrous pipes shall be supported by (galvanized) steel pipe attachment, unless otherwise specified.

D. All uninsulated copper and/or thermoplastic piping shall be supported by plastic coated or copper plated steel pipe attachments.

E. All piping shall be braced as required, to prevent sway in any direction.

F. All insulated hot and cold water piping 2-1/2-inch diameter and larger shall be supported by roller hangers conforming to FS WW-H-171E, Type 42.

G. Do not use expansion anchors in the Work.

3.2 INSTALLATION

A. Supports and Hangers for Horizontal Pipes:
   1. Space supports and hangers for all piping no farther apart than shown below, unless otherwise shown on the Drawings:
      a. Copper Tube:
         1) All Pipes: 6 feet-0 inch center.
      b. Steel Pipe:
         1) Pipes up to 1-inch: 6 feet-0 inch center.
         2) Pipes 1-1/4-inch to 6-inch: 8 feet-0 inch center.
      c. Cast-Iron Pipe:
         1) Two supports per length.
      d. Plastic Pipe:
         1) 3 feet-0 inch on center for all sizes, unless otherwise recommended by manufacturer for 120°F ambient temperature.
   2. Additional supports shall be placed immediately adjacent to any change in piping direction, and on both sides of valves and couplings.
   3. Accurately locate inserts for hanger rods in forms before concrete is placed.

B. Hanger Rods: Size hanger rods according to the schedule below, unless otherwise shown on the Drawings:

NOMINAL PIPE (INCHES)	ROD DIAMETER (INCHES)
1/2 - 2	3/8
2-1/2 - 3	1/2
4 - 5	5/8
6	3/4
8 - 12	7/8

C. Supports for Vertical Piping:
   1. Provide riser clamp placed under hub, fitting or coupling with approved solid bearing on steel sleeve at each floor level.
   2. Where riser clamps are used with plastic piping they shall be modified so as not to exert any compressive forces on the pipe.
   3. Piping support intervals shall not exceed those listed in Paragraph 3.2.A., above.
   4. Additional supports shall be placed immediately adjacent to any change in piping direction, and on both sides of valves and couplings.
   5. Accurately locate inserts for hanger rods in forms before concrete is placed.
   6. Support spacing shall not exceed the Phoenix Plumbing Code.

D. Supports for water meters and backflow preventers: Provide pipe saddle supports with base anchored to floor.

E. Structural members shall conform to Section 05120, Structural Steel.

F. Anchor bolts, expansion anchors and concrete inserts shall conform to Section 05051, Anchor Bolts, Toggle Bolts and Concrete Inserts.

G. Miscellaneous metal fabrications shall conform to Section 05501, Miscellaneous Metal Fabrications.

H. Allow clearances for expansion and contraction of piping.

I. Anchors shall be designed to prevent any pipe movement at pipe anchorage points. Anchors shall be securely fastened to the construction directly or indirectly through structural framing:
   1. Piping 2-1/2-inches and Smaller: Anchor horizontal runs over 50 feet to midpoint to allow expansion toward expansion compensators (anchor intervals shall not exceed 30 feet) or elbows.
   2. Piping 3-inches and Larger: Anchor horizontal runs over 100 feet at mid points to force expansion toward expansion compensators.
   3. Provide alignment guides in accordance with expansion compensator manufacturer recommendations.

J. Provide expansion compensators, where necessary, to absorb expansion and contraction in heating lines and as follows:
   1. 30 feet on center of copper piping.
   2. 50 feet on center of steel piping.

K. Locate first set of alignment guides within four pipe diameters of the anchor or expansion compensator, the second set of pipe alignment guides shall be located within fourteen pipe diameters of the first guides.

L. Do not hang piping from ductwork or other piping.

3.3 PAINTING

A. Conform to Section 09900, Painting.

+ + END OF SECTION + +

SECTION 15151

WASTE AND VENT PIPING SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish and install a complete waste and vent piping system including all floor drains, equipment and all soil, waste, drain and vent piping to the limits shown on the Drawings.

1.2 QUALITY ASSURANCE

A. Manufacturer's Qualifications:
   1. Manufacturer shall have a minimum of five years of experience of producing substantially similar equipment, and shall be able to show evidence of at least five installations in satisfactory operation for at least five years.

B. Requirements of Regulatory Agencies:
   1. Building Codes: Comply with applicable requirements of all governing authorities and the following codes:
      a. Phoenix Plumbing Code.
   2. Permits: Obtain and pay for all required permits, fees and inspections by authorities having jurisdiction.

C. Reference Standards: Comply with applicable provisions and recommendations of the following, except as otherwise shown or specified:
   1. ANSI A21.6, Cast-Iron Pipe Centrifugally Cast in Metal Molds, for Water or Other Liquids.
   2. ANSI A21.11, Rubber Gasket Joints for Case-Iron and Ductile-Iron Pressure Pipe and Fittings.
   3. ANSI A21.50, Thickness Design of Ductile-Iron Pipe.
   4. ANSI A21.51, Ductile-Iron Pipe, Centrifugally Cast, in Metal Molds or Sand-Lined Molds for Water or Other Liquids.
   5. ANSI A112.5.1, Cast Iron Soil Pipe and Fittings.
   6. ANSI B16.12, Cast-Iron Threaded Drainage Fittings.
   7. ASTM A 53, Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless Steel.
   8. ASTM A 74, Specification for Cast Iron Soil Pipe and Fittings.
   9. ASTM A 518, Specification for Corrosion-Resistant High-Silicon Iron Castings.
   10. ASTM A 861, Specification for High-Silicon Iron Pipe and Fittings.

11. ASTM A888, Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste and Vent piping applications.
12. ASTM C564, Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings.
13. ASTM D1248, Specification for Polyethylene Plastics Molding and Extrusion Materials.
14. ASTM D1784, Specification for Rigid Poly (Vinyl Chloride) PVC Compounds and Chlorinated Poly (Vinyl Chloride) CPVC Compounds.
15. ASTM F439, Specification for Chlorinated Poly (Vinyl Chloride) CPVC Plastic Pipe Fittings, Schedule 80.
16. ASTM F441, Specification for Chlorinated Poly (Vinyl Chloride) CPVC Plastic Pipe, Schedules 40 and 80.
17. CISPI 310 Couplings for Use in Connection with Hubless Cast Iron Sanitary and Storm Drain, Waste and Vent Piping Applications.
18. CISPI HSN, Neoprene Rubber Gaskets for Hub and Spigot Cast Iron Soil Pipe and Fittings.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Manufacturers literature, specifications, and engineering data including, dimensions, size and material of the following:
      a. Piping and fittings.
      b. Floor and equipment drains.
      c. Floor and wall cleanouts.
   2. Drawings on a 1/4-inch scale showing materials and dimensions of the complete waste and vent piping system, in plan and in section.

B. Record Drawings: During progress of the Work keep an up-to-date set of drawings showing field and Shop Drawing modifications. Immediately upon completion of piping Work submit mylar drawings showing the actual in-place installation of all piping and equipment installed under this Section, at a scale satisfactory to the OWNER. The drawings shall show all piping on plans and in sections, with all reference dimensions and elevations required for complete "Record Drawings" of the piping systems. Two paper prints shall also be furnished. The mylar drawings shall be furnished not later than 30 days after Final Acceptance of the Contract and prior to final payment.

1.4 JOB CONDITIONS

A. Protection: Properly plug or cap the open ends of all pipe at the end of each days' Work or other stopping point throughout construction. Equipment shall be tightly covered and protected against dirt, water and chemical or mechanical injury.

B. All excavation and backfill required for piping installed under this Section shall conform to Section 15051, Buried Piping Installation.

PART 2 - PRODUCTS

2.1 PIPING

A. Cast Iron Soil Pipe and Fittings:
   1. Pipe and Fittings: ASTM A 74.
   2. Weight: Service Weight.
   3. Joints:
      a. Compression:
         1) Gasket: Neoprene Rubber, ASTM C 564, CISPI HSN.
         2) Lubricant: As recommended by pipe manufacturer.

B. Steel Pipe and Fittings:
   1. Pipe: ANSI B125.2.
   2. Weight: Schedule 40.
   3. Finish: Galvanized.
   4. Fittings: ANSI B16.12 recessed drainage pattern galvanized cast-iron, threaded so as to allow 1/8-inch or 1/4-inch per foot grade, as required.

C. Hubless Cast Iron:
   1. No-Hub Pipe and Fittings: ASTM A 888.
   2. Joints: CISPI Standard No. 310.

D. Chlorinated Polyvinyl Chloride Pipe and Fittings:
   1. Pipe: ASTM D 1784 and ASTM F 441, Class 23447-B.
   2. Weight: Schedule 80.
   3. Fittings: ASTM F 439.
   4. Joints:
      a. Solvent weld with manufactures recommended solvents.

E. High Silicon Cast Iron Pipe:
   1. Silicon Content: 14.5 percent.
   2. Weight: 0.255 lbs. per cubic inch.
   3. Melting Point: 2,300°F.
   4. Hardness, Brinell: 520.
   5. Tensile Strength (1/2-inch diameter): 20,000 psi.
   6. Joints: Hub and spigot with acid, resistant packing followed by lead.
   7. Fittings: Same material as pipe.
   8. Reference: ASTM A 518 and ASTM A 861.

2.2 DRAINS AND CLEANOUTS

A. Drains and Cleanouts:
   1. Floor Drain and Shower Drain: (FD-1).
      a. Materials:
         1) Body: Enameled cast iron.
         2) Collar: Cast iron, reversible, threaded for strainer heads, enamel coated.
         3) Strainer Head: Square 8-inch by 8-inch nickel bronze grate with bronze body, heel proof grate, and vandal proof screws.
      b. Outlet Connection: Bottom outlet, caulk or no-hub, as required.
      c. Trap primer connection on body with thread to solder adapter, as required.
      d. As manufactured by one of the following:
         1) Jay R. Smith.
         2) Zurn Industries.
         3) Or equal.
   2. Floor Drain, General Purpose: (FD-2).
      a. Materials:
         1) Body: Enameled cast iron.
         2) Collar: Enameled cast iron.
         3) Top: Enameled cast iron adjustable.
         4) Grate: Ductile iron, 11-1/2-inch diameter.
      b. Accessories: Sediment bucket.
      c. Rating: Heavy duty.
      d. Outlet Connection: Bottom outlet, no-hub, as required.
      e. Floor drains in the Biofilter or connected to lift station wet wells shall be coated with an acid resistant coating.
      f. As manufactured by one of the following:
         1) Jay R. Smith.
         2) Zurn Industries.
         3) Or equal.
   3. Floor Drain, Funnel Drain: (FD-3).
      a. Type: Medium duty funnel drain.
      b. Materials:
         1) Body: Enameled cast iron.
         2) Collar: Enameled cast iron.
         3) Top: Enameled cast iron, adjustable, 12-inch diameter minimum.
         4) Grate: Cast iron.
         5) Funnel: Cast iron, oval.
      c. Accessories:
         1) Sediment bucket.
         2) Vandal proof.
      d. Rating: Medium duty.
      e. Outlet Connection: Bottom outlet, no-hub, as required.

f. Floor drains in the Biofilter or connected to lift station wet wells shall be coated with an acid resistant coating.
g. As manufactured by one of the following:
   1) Jay R. Smith.
   2) Zurn Industries.
   3) Or equal.

4. Floor Drain, Large Flows: (FD-4).
   a. Type: Extra deep receptor.
   b. Materials:
      1) Body: Cast-iron with acid resistant interior.
      2) Collar: Cast-iron with acid resistant interior.
      3) Grate and Rim: Nickel bronze with 8-inch square hole in center of grate.
      4) Strainer: None required.
   c. Outlet: Bottom outlet, caulk, as required.
   d. As manufactured by one of the following:
      1) Jay R. Smith.
      2) Wade Division/Tyler Pipe Co. .
      3) Or equal.
5. Floor Drain, General Purpose: (FD-5).
   a. Type: Heavy duty process area drain.
   b. Materials:
      1) Body: Enameled cast iron.
      2) Collar: Enameled cast iron.
      3) Top: Enameled cast iron adjustable 10-inch or 12-inch diameter.
      4) Grate: Ductile-iron.
   c. Accessories:
      1) Sediment bucket.
      2) Vandal proof.
   d. Rating: Heavy duty.
   e. Outlet Connection: Threaded, as required.
   f. As manufactured by one of the following:
      1) Jay R. Smith.
      2) Zurn Industries.
      3) Or equal.
6. Floor Drain, (F.D. W/CODP):
   a. Materials:
      1) Body: Enameled coated cast iron with hinged ductile-iron grate and sediment bucket with deep seal trap and bronze cleanout plug.
   b. Outlet Connection: Inside thread, as required.
   c. As manufactured by one of the following:
      1) Jay R. Smith.
      2) Zurn Industries.
      3) Or equal.

7. Floor Drain: (FD-6).
   a. Type: Deep receptor drains with half grate.
   b. Materials:
      1) Receptor: Cast iron, flanged with acid resistant enamel coated interior.
      2) Rim and Grate: Nickel bronze.
   c. Outlet Connection: Caulk.
   d. As manufactured by one of the following:
      1) Jay R. Smith.
      2) Zurn Industries.
      3) Or equal.
8. Floor Drain: Acid Resistant Drain: (FD-7).
   a. Type: Acid resistant floor drain.
   b. Materials: All chlorinated polyvinyl chloride (CPVC) construction.
   c. Outlet Connection: Solvent weld hub outlet, as required.
   d. As manufactured by one of the following:
      1) R and G Sloane.
      2) Ryan Herco.
      3) Or equal.
9. Trench Drains: (T.D.).
   a. Materials:
      1) Body: Cast iron.
      2) Dome: Cast iron.
   b. Outlet Connection:
      1) Inside caulk.
   c. As manufactured by one of the following:
      1) Jay R. Smith.
      2) Zurn Industries.
      3) Or equal.
10. Equipment Drain: (E.D. W/CODP).
    a. Materials:
       1) Body: Enamel coated cast iron.
       2) Grate: Hinged type ductile-iron.
       3) Plug: Bronze cleanout.
       4) Bucket: Cast sediment bucket.
       5) Trap: Deep seal type, 5-inch minimum seal.
    b. Funnel:
       1) As manufactured by one of the following:
          a) Jay R. Smith.
          b) Zurn Industries.
          c) Or equal.
    c. Materials:
       1) Body: Enameled cast iron.
       2) Fasteners: Bronze securing screws and washers.

d. As manufactured by one of the following:
   1) Jay R. Smith.
   2) Zurn Industries.
   3) Or equal.

11. Equipment Drain: (ED-1).
    a. Type: Funnel with trap.
    b. Materials:
       1) Funnel: Duco coated cast iron.
       2) Strainer: Duco coated cast iron.
       3) Trap: Duco coated cast iron "P" trap.
    c. As manufactured by one of the following:
       1) Jay R. Smith.
       2) Zurn Industries.
       3) Or equal.
12. Equipment Drain: (ED-2).
    a. Type: Drip or condensate funnel.
    b. Materials: Cast bronze.
    c. Strainer: Cast bronze dome bottom strainer.
    d. As manufactured by one of the following:
       1) Jay R. Smith.
       2) Zurn Industries.
       3) Or equal.

B. Cleanouts:
   1. Cleanout Deck Plates (Finished Areas) FCO-1:
      a. Materials: Cast iron body and adjustable nickel bronze top.
      b. Outlet Connection: Standard spigot.
      c. Accessories:
         1) Square nickel bronze top.
         2) Cast bronze taper thread plug.
      d. As manufactured by one of the following:
         1) Jay R. Smith.
         2) Zurn Industries.
         3) Or equal.
   2. Cleanout Deck Plate (Traffic Areas) FCO-2:
      a. Materials: Cast iron body, flanged housing, cast iron cover with fitting device.
      b. Outlet Connection: Caulk outlet.
      c. As manufactured by one of the following:
         1) Jay R. Smith.
         2) Zurn Industries.
         3) Or equal.
   3. Wall Cleanout Plate:
      a. Materials: Cast bronze taper thread plug.

b. Accessories:
   1) Stainless steel round shallow wall plate.
   2) Cast iron caulked ferrule.
c. As manufactured by one of the following:
   1) Jay R. Smith.
   2) Zurn Industries.
   3) Or equal.

C. Neutralization Tank:
1. Materials:
   a. Tank: High density polyethylene.
   b. Cover: Polyethylene, bolt down.
   c. Gasket: Neoprene.
   d. Nuts, Bolts and Washers: Stainless steel.
2. Connections:
   a. Inlet: 2-inch.
   b. Outlet: 2-inch.
   c. Vent: 2-inch.
3. Capacity: Five gallon nominal.
4. Approximate Pounds of Limestone Chips: 50 lbs.
5. Wall Thickness: 3/16-inch minimum.
6. Fill with limestone or marble chips one to three inches in size to a level just below tank outlet.
7. As manufactured by one of the following:
   a. Enfield Industrial Corporation, Neutratank.
   b. Orion Industries, Incorporated, Style 5.
   c. Or equal.

D. Trap Primers:
1. Type: Automatic floor drain trap primer valve.
2. Connections: 1/2-inch inlet and 1/2-inch outlet.
3. Accessories:
   a. Distribution units.
   b. Vacuum breaker.
4. Product and Manufacturer: Provide one of the following:
   a. Precision Plumbing Products, Inc., Fig. PO-500.
   b. Or equal.

2.3 MATERIAL SELECTION

A. All exposed gravity sanitary waste and vent piping run within the interior of a building shall be no-hub cast iron. Concealed gravity waste and vent piping lines may be steel or hubless cast iron. Provide adapters, as required.

B. All gravity sanitary waste and vent piping located in concrete slabs or underground to exterior limits as shown on the Drawings shall be service weight cast iron soil pipe, unless otherwise noted.

C. All acid resistant waste piping and all acid resistant vent piping shall be:
   1. Chlorinated polyvinyl chloride (CPVC).

D. Floor drains shall be furnished with trap primer connections, as shown on the Drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation of drains and cleanouts shall be in accordance with manufacturer's instructions and recommendations.

B. Installation of piping shall be in accordance with Section 15143, Installation of Plumbing Piping.

C. All waste and vent piping in chases shall pitch uniformly at a 1/4-inch per foot grade, otherwise waste and vent piping shall pitch uniformly at 1/8-inch per foot grade, unless otherwise shown on the Drawings.

D. Trap primers and distribution units shall be furnished and installed where shown on the Drawings and as required by the Phoenix Plumbing Code.

E. Accessible cleanouts shall be furnished and installed as shown on the Drawings and as required by the Phoenix Plumbing Code.

F. Plastic hub and spigots shall be provided for adapting CPVC pipe to cast iron fittings.

G. Provide 18 gage galvanized steel drip pans under all pipes that pass over or near electrical control equipment. Drip pans shall be furnished with 1-1/2-inch diameter "tell-tale" drains terminating 6-inches above the floor in a corner or near a column.

3.2 FIELD QUALITY CONTROL

A. Tests: Water or smoke test in accordance with Section 15015, Piping Systems, and Section 15144, Testing of Plumbing Piping System.

+ + END OF SECTION + +

SECTION 16050

GENERAL PROVISIONS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment, and incidentals as shown on the Drawings, specified, and required to complete the electrical Work.
   2. Equipment shall be rated and labeled by the manufacturer for the environmental conditions in which it is installed including the power disconnects, control stations, and wiring systems.
   3. Conduits and circuits within electrical distribution or utilization equipment and cabinets shall be identified and labeled as specified and as shown.

B. Coordination:
   1. Review installation procedures, drawings and schedules under other Sections and coordinate with other trades the installation of electrical items that must be installed with or within formwork, walls, partitions, ceilings and panels.
   2. Responsible for the installation of all conduits, inserts, and other items to be embedded in the concrete, or built into walls, partitions, ceilings or panels constructed by other contractors. Provide other contractors with detailed plans or sketches of the location of said conduits and other built-in items as may be required. Stay fully informed of the construction where conduits and other built-in items are to be installed. Install said conduits and other built-in items in such a manner and within such time periods as will not unnecessarily delay the work of the other contractors.
   3. Arc Flash Coordination: Review Electrical Pre-Submittal coordination efforts during the Pre-Construction Conference, section 01301 with CONTRACTOR, STUDY FIRM, ARC FLASH FACILITATOR and the ENGINEER.
      a. Agenda items for Pre-Construction Conference shall include:
         1) Submittal review routing protocols.
         2) Discuss procedures to handle equipment found to have an incident energy level that requires above a Level 2 PPE.
         3) Electrical safety label installation, as identified in specification 16215.
         4) Single Line Diagram and Power Panel Schedule Record Documents.

C. General:
   1. Interpretation of Drawings:
      a. Dimensions shown on the Drawings that are related to equipment are based on the equipment of one manufacturer. Confirm the dimensions of the equipment furnished to the space allocated for that equipment.

b. The Drawings show the principal elements of the electrical Work. They are not intended as detailed working drawings for the electrical Work, but as a complement to the Specifications to clarify the principal features of the electrical systems.
c. It is the intent of the Drawings and Specifications that all equipment and devices, furnished and installed under this Contract, be properly connected and interconnected with other equipment and devices so as to render the installations complete for successful operation, regardless of whether all the connections and interconnections are specifically mentioned in the Specifications or shown on the Drawings.
d. It also is the intent of the Contract Documents that similar products are provided by the same manufacturer for uniformity on the Project.

D. Temporary Power and Lighting:
1. Refer to Section 01511, Temporary Electricity, for temporary power during construction.
2. Refer to Section 01512, Temporary Lighting, for temporary lighting during construction.
3. If utilizing existing facility power, provide updated panel schedules and/or load summaries to the ENGINEER and OWNER identifying the recommended power sources and circuits for temporary services. ENGINEER and OWNER must provide approval prior to connecting to the services.

1.2 QUALITY ASSURANCE

A. Requirements of Regulatory Agencies:
1. Permits: Obtain all permits and pay fees required to commence Work and, upon completion of the Work, obtain and deliver to the ENGINEER a Certificate of Inspection and Approval from the authority having jurisdiction.
2. Codes: Material and equipment shall be installed in accordance with the current standards and recommendations of the National Electrical Code, the National Electrical Safety Code and with local codes which apply. Where discrepancies arise between codes, the most restrictive regulation shall apply.
3. Tests by Independent Regulatory Agencies: Electrical material and equipment shall be new and shall bear the label of the Underwriters' Laboratories, Inc., or other nationally-recognized, independent testing laboratory, wherever standards have been established and label service regularly applies.

B. Reference Standards: Electrical material and equipment shall conform in all respects to the latest approved standards of the following:
1. National Electrical Manufacturers Association (NEMA).
2. The American National Standards Institute (ANSI).
3. The Institute of Electrical and Electronic Engineers (IEEE).
4. Insulated Cable Engineers Association (ICEA).
5. National Electrical Code (NEC) current adoption.
6. National Electrical Safety Code (NESC).

7. American Society for Testing and Materials International (ASTM).
8. The Instrumentation, Systems and Automation Society (ISA).
9. National Fire Protection Agency (NFPA).
10. Underwriter's Laboratories, Inc. (UL).
11. Occupational Safety and Health Administration (OSHA).

C. Wiring Coordinator:
   1. Retain the services of a Wiring Coordinator who shall prepare complete point-to-point interconnection wiring termination sheets. The sheets shall identify all external interconnecting wiring associated with all new and modified existing equipment.
      a. Qualifications: Coordinator shall have experience in the development of the point-to-point interconnection wiring termination sheets and shall have served in a similar role on a project of similar size and complexity.
         1) Present qualifications and approach for the project at Pre-Construction Conference specified under Section 01301, Pre-Construction Conference.
         2) Prepare the items listed below for presentation at the Pre-submittal Meeting. Submit to ENGINEER three weeks prior to date of meeting.
            a) List of projects where the Wiring Coordinator developed point-to-point wiring termination sheets.
            b) Samples of diagrams that were developed for the listed projects.
            c) Example wiring diagram proposed for the Work with a preliminary list of drawings to be produced.
            d) Plan of how information will be obtained and documented.
      b. Responsibilities:
         1) Develop point-to-point interconnection wiring termination sheets for performance of the Work and to document terminations.
         2) Use information obtained from approved Shop Drawings, Record Drawings and field inspections as required to complete the sheets. **Note that as-building of the existing control and instrumentation system will be required. In addition, as-building of the existing power distribution system will also be required.**
         3) Attend Pre-submittal Meeting and periodic coordination and progress meetings specified in Section 17001, Process Control System General Requirements for Process Instrumentation.
         4) Conduct point-to-point wiring checks to determine wires and terminations are per the point-to-point interconnection wiring termination sheets. CONTRACTOR to sign-off on the sheets to document the checks were performed. After confirmation by the CONTRACTOR, submit the signed sheets to the OWNER/ENGINEER.
            a) Point-to-Point Interconnection Wiring Termination Sheets: Include the following:

i. External wiring for each piece of equipment, panel, instrument and other devices and conduit wiring to control stations, lighting panels and motor controllers.
ii. Numbered terminal block identification for each wire termination.
iii. Identification of the assigned wire numbers for all interconnections.
iv. Identification of all conduit wiring by the conduit tag in which the wire is installed.
v. Terminal and pull boxes through which wiring is routed.
vi. Identification of all equipment and the Shop Drawing transmittal numbers for equipment from which the wiring requirements and termination information was obtained.

1.3 SUBMITTALS

A. Refer to Section 01330, Submittals and Section 01332, Shop Drawing Procedures.

B. Shop Drawings shall include the following information to the extent applicable to the particular item:
1. Manufacturer's name and product designation or catalog number, including environmental rating such as "Rated for Outdoor Use" or "Rated for Hazardous Location".
2. Electrical ratings.
3. Conformance to applicable standards or specifications of ANSI, ASTM, ICEA, IEEE, ISA, NEC, NEMA, NFPA, OSHA, UL, or other organizations.
4. Dimensioned plan, section, elevations and panel layouts showing means for mounting, conduit connection, and grounding.
5. Materials and finish specification, including paints.
6. List of components including manufacturer's names and catalog numbers.
7. Internal wiring diagram and drawings indicating all connections to components and numbered terminals for external connections.

1.4 PROJECT CLOSEOUT

A. Operation and Maintenance Data: Submit complete manuals including:
1. Copies of all Record Drawings and Wiring Diagrams, test reports, Power System Study, maintenance data and schedules, description of operation, and spare parts information.
2. Furnish Operation and Maintenance Manuals in conformance with the requirements of Section 01781, Operation and Maintenance Data.

B. Record Drawings:
1. Furnish four (4) copies of Record Drawings in accordance with the requirements of Section 01782, Record Documents, including:

a. System Record Drawings: Include the following:
   1) One line wiring diagram of the distribution system.
   2) Accurate and detailed in place conduit and cable layouts with schedule of conduit sizes and number and size of conductors.
   3) Layouts of the power and lighting arrangements and the grounding system.
   4) Control schematic diagrams, with terminal numbers and all control devices identified, for all equipment.
   5) Point-to-Point Interconnection Wiring Termination Sheets

2. The Record Drawings shall reflect final equipment and field installation information.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Delivery of Materials: Instruct the manufacturers and vendors as to the maximum shipping sizes of equipment that can be accommodated at the site.

B. Storage of Materials: Refer to and comply with the requirements of Section 01661, Storage of Materials and Equipment.

C. Handling of Materials: Refer to and comply with the requirements of Section 01651, Transportation and Handling of Materials and Equipment.

1.6 JOB CONDITIONS

A. Existing Conditions:
   1. Examine the site and existing facilities in order to compare them with the Contract Documents with respect to the conditions of the premises, location of and connection to existing facilities and any obstructions which may be encountered.
   2. Perform the Work with due regard to safety and in a manner that will not interfere with the existing equipment or in any way cause interruption of any of the functions of the plant.
   3. Work shall be carried out with a minimum amount of disruption to the operation of the existing plant and with prior approval of OWNER. Submit for approval by OWNER, a detailed written procedure for work which affects operation of the existing plant, a detailed procedure for modifying any existing electrical equipment, including appropriate Personal Protective Equipment (PPE) required if equipment must remain energized while conducting work, anticipated time required to complete the Work, and the required shutdown time, if any.
   4. Where the Work of CONTRACTOR ties in with existing installations, take prior precautions and safeguards in connecting the Work with the existing operating circuits so as to prevent any interruption to the existing operating circuits. The tying in of Work, installed under this Contract, with the existing circuits shall be performed only in the presence of OWNER. Advance notice will be required

before any equipment is removed from service. Notify OWNER, in writing, of his intention to do such work, providing full details.

B. Demolition:
   1. The demolition of electrical power distribution equipment, instrumentation/ control equipment, conduit, wire and appurtenances shall be in accordance with Section 02220, Demolitions.

1.7 CONTROL CABINETS AND PANELS

A. All outdoor panels:
   1. With electronics and temperature sensitive instruments, shall be provided with sunshade structures. Sunshade structures shall be constructed as shown on drawings.
   2. Shall be Free-Stand Enclosures
B. All control cabinet and panel materials shall meet the area classifications as stated is Section 1.9, unless otherwise specified or noted on the Drawings.
   Proved the following types of enclosures:
   1. NEMA **3R, 4 or 12**
   2. Corrosive Locations, NEMA 4X
   3. Hazardous Locations, NEMA 7
C. Provide the following enclosure features:
   1. NEMA 3R, 4 or 12 Enclosures:
      a. Fabricate enclosures using minimum 14 gage steel for wall or frame mounted enclosures and minimum 12 gage for free standing enclosures. Keep steel free of pitting and surface blemishes.
      b. Continuously weld all exterior seams and grind smooth. Also, surface grind complete removal of corrosion, burrs, sharp edges and mill scale.
      c. Reinforce sheet steel with steel angles where necessary to adequately support equipment and ensure rigidity and to preclude resonant vibrations.
      d. Provide control panel with flatness within 1/16-inch over a 24-inch by 24-inch area, or flat within 1/8-inch for a larger surface. Verify flatness by using a 72-inch long straight edge. Limit out-of-flatness to gradual and in one direction only with no obvious depressions or wavy sections.
      e. Use pan type construction for doors. Door widths are not to exceed 36-inches.
      f. Mount doors with heavy duty hinge(s) with stainless steel hinge pins.
      g. Provide handle-operated, oil-tight, key-lockable three point stainless steel latching system with rollers on latch-rods for easy door closing.
      h. Product and Manufacturer: Provide one of the following:
         1) Hoffman
         2) Hammond
      i. Painting:
         1) Completely clean all interior and exterior surfaces so they are free of corrosive residue, oil, grease and dirt. Apply zinc phosphate for corrosion protection.

2) Apply one coat of primer interior and exterior surfaces immediately after corrosion protection has been applied.
3) Coat exterior surfaces with primer surface applied with sanding and cleaning between coats, until a Grade 1 finish can be produced on the finish coat.
4) Paint all exterior surfaces minimum of three finish coats of polyurethane enamel to ultimately produce a Grade 1 finish (super smooth; completely free of imperfections). Color to be selected by ENGINEER from complete selection of standard and custom color charts furnished by the manufacturer. Provide one extra quart of touch-up paint for each exterior finish color.
5) Provide compatible primer and finish paint with a low VOC, high solids polyurethane enamel. Paint interior surfaces with two coats of semi-gloss white polyurethane enamel.
6) Product and Manufacturer:
   a) Hi-Solids Polyurethane B65 W300 Series as manufactured by Sherwin Williams, Inc
   b) Or equal.

3. NEMA 4X Enclosures:
   a. Provide enclosures with Type 316 stainless steel construction. Wall or frame mounted enclosures fabricate using a minimum 14 gage steel. Free standing enclosures fabricate using a minimum 12 gage steel. Enclosures smaller than 14”x 12”x 6” fabricate using a minimum of 16 gage steel. Keep steel free of pitting and surface blemishes. Provide all surfaces with a smooth brushed finish.
   b. Provide stainless steel fast-operating clamp assemblies on three sides of each door.
   c. Rolled lip around three sides of door and along top of enclosure opening.
   d. Provide a hasp and staple for padlocking.
   e. Provide 3-inch high channel base assembly, with solid bottom, drilled to mate the panel to its floor pad for free-standing panel.
   f. Provide 5/16-inch diameter copper ground studs for the ground connection points for all panel equipment and panel doors.
   g. Product and Manufacturer: Provide one of the following:
      1) Hoffman
      2) Hammond

4. NEMA 7 Enclosures;
   a. House monitoring and measuring devices located in hazardous environments in explosion-proof control enclosures.
   b. Enclosures rated for use in NEC Class 1, Groups C&D or Class II, Groups E, F & G applications and comply with UL and CSA standards.
   c. Required Features:
      1) Light weight and corrosion resistant copper-free aluminum
      2) Integral, cast-on mounting lugs

3) Left side door hinges
4) Viewing windows sized to suit internally mounted components
5) Stainless steel cover bolts
6) Cad-plated steel mounting pans

d. Product and Manufacturer: Provide one of the following:
1) Adalet
2) Killark
3) Crouse-Hinds
4) Hoffman

1.8 ELECTRICAL EQUIPMENT

A. All electrical equipment shall be capable of operating successfully at full-rated load, without failure, with an ambient outside air temperature range of -10°F to 131°F and an elevation of 1090 feet (MSL).

B. All electrical devices and equipment shall have ratings based on 75°C terminations.

C. Mounting of electrical equipment on handrails is not allowed.

1.9 AREA CLASSIFICATIONS

A. Materials and equipment shall conform to the area classification(s) shown on the Drawings, specified and required.

B. Materials, equipment and incidentals in areas identified as hazardous locations shall meet NEC requirements for the Class and Division designated.

1.10 SCHEMATIC DIAGRAMS

A. Schematic diagrams are provided for CONTRACTOR'S guidance in fulfilling the operational intent of the Contract Documents.

B. Responsibility belongs to CONTRACTOR to meet all safety and electrical codes, and to provide all equipment, appurtenances and specialty items required to provide for complete and operable systems.

C. Review of control schemes submitted by CONTRACTOR does not relieve CONTRACTOR of his contractual responsibility to provide complete and successfully operating systems.

PART 2 - PRODUCTS

2.1 NAMEPLATES

A. Material: Laminated phenolic, engraved to show 1/2-inch high letters, Arial Font, unless stated else where in the CONTRACT DOCUMENTS for a specific piece of equipment. The letters shall be black with white background or match existing.

B. Border: Minimum 1/8-inch around engraved print with extra length for fastening devices.

C. Fasteners: Secured with #4-40, round-head, stainless steel, self-tapping screws.

2.2 WIRE MARKERS

A. Refer to Section 16122, 600 Volt Cable.

2.3 CONDUIT TAGS

A. Refer to Section 16131, Rigid Conduit.

PART 3 - EXECUTION

3.1 EQUIPMENT IDENTIFICATION

A. Provide identification of each electrical item, in addition to the manufacturer's nameplates, to identify the item's function, and the equipment or system which it serves or controls.

B. Identify equipment by means of nameplates. Re-label existing equipment whose designation has been changed. Identify potential arc flash hazard levels on equipment with the label specified in Section 16215 – Power Study.

C. Identify pull and terminal boxes with nameplates. Identify each box by a unique number. Numbering system shall reflect the actual designations used in the field and as documented on wiring diagrams.

D. Process/Mechanical/Electrical equipment located outdoors shall be labeled by the manufacturer: "For Outdoor Use".

E. Equipment Voltage Labels:
   1. Voltage labels shall be installed on all equipment that has voltage in the equipment.
   2. Where applicable, install voltage label below the Arc Flash Warning label.
   3. If the equipment has access to the backs or side of the gear, apply voltage labels on all access panels.
   4. Provide standard 3.5-inch by 5-inch, Black/Red on White rectangular labels to match Figure 2.2.C below.

5. Apply a "Danger High Voltage" label to all medium equipment greater than 600 volts.
6. Product and Manufacture: Provide the following:
   a. BRADY
      1) DANGER 120 VOLTS, Part # 86784
      2) DANGER 208 VOLTS, Part # 86782
      3) DANGER 240 VOLTS, Part # 86785
      4) DANGER 480 VOLTS, Part # 86783
      5) DANGER HIGH VOLTAGE INSIDE, Part # 86861
   b. Or Equal.

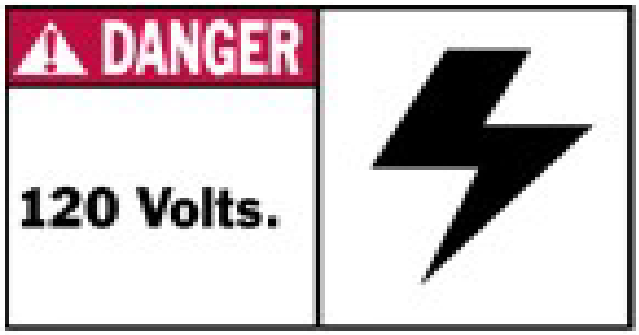

Figure 2.2.C

F. Service Entrance Sections:
   1. Install a Danger Electrical Hazard & Voltage placard on the front side of all Service Entrance Sections.
      a. Placard to be Black/Red on White on aluminum and size to be 7 – inch by 10 – inch to match Figure 2.2.D below.
      b. Install 1.75 inch x 3.5 inch, type printed, high performance polyester appropriate voltage level labels on the placard. Hand written is not allowed
   2. If the Service Entrance Section has access to the backs or side of the gear, apply voltage labels per Paragraph 2.2.C above and Arc Flash Potential Warning labels per Paragraph 2.2.B.2 on all access panels at each main breaker.
   3. Product and Manufacture: Provide the following:
      a. BRADY
         1) DANGER _____ VOLTS, Part # 43141
      b. Or Equal

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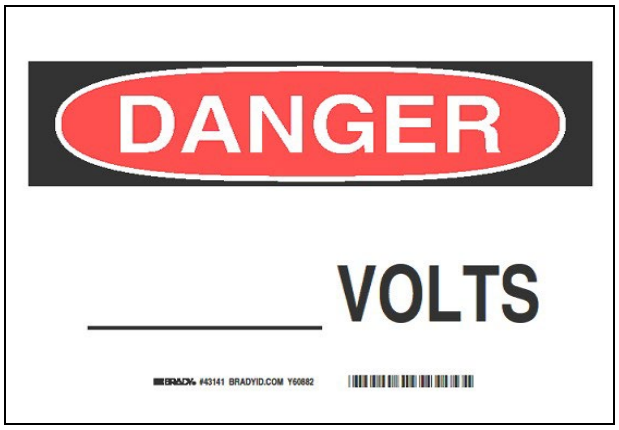

Figure 2.2.D

G. Utility Sections:
   1. When the Utility Sections has access to the back, apply a standard 3.5-inch by 5-inch, Black/Red on White rectangular "DANGER" label stating to match Figure 2.2.E below and Arc Flash Potential Warning labels per Paragraph 2.2.B.2.
   2. Product and Manufacture: Provide the following:
      a. BRADY
      b. Or Equal

Figure 2.2.E

H. Additional Sources of Power:
   1. When more than one source of power is located inside the equipment apply standard 3.5-inch by 5-inch, Black/Red on White rectangular "DANGER" label stating to match Figure 2.2.F below.
   2. Product and Manufacture: Provide the following:
      a. BRADY
      b. Or Equal

Figure 2.2.F

I. Generator Power Sources:
   1. There are to be no Arc Flash Potential Labels printed or applied pertaining to any system that has generation power as an alternate source. For these sites apply at the automatic transfer switch a standard 3.5-inch by 5-inch, Black on Orange "WARNING" label stating to match Figure 2.2.G below
   2. Product and Manufacture: Provide the following:
      a. BRADY
      b. Or Equal

++ END OF SECTION ++

SECTION 16061

GROUNDING SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish and install complete grounding for the electrical systems, structures and equipment.
   2. Pump cans and buried piping shall be bonded to the ground grid.

1.2 QUALITY ASSURANCE

A. Reference Standards: Comply with applicable provisions and recommendations of the following, except where otherwise shown or specified:
   1. National Electrical Code (NEC) Article 250, Grounding.
   2. Underwriters Laboratories (UL) Standard No. 467, Electrical Grounding and Bonding Equipment.
   3. ANSI-J-STD-607-A, Commercial Building Grounding [Earthing] and Bonding Requirements for Telecommunications.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Manufacturer's technical information for grounding materials proposed for use.
   2. Listing of grounding connector types identifying where they are to be used.
   3. Layouts of each structure ground grid.
   4. Test point construction details.
   5. Ground resistance test procedure.
   6. Results of ground resistance tests at each test point. Provide the test information and results as required on form 16000-N in Specification 01331 – Reference Forms.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Bare Ground Cable:
   1. Material: Annealed, bare, stranded copper.
   2. Product and Manufacturer: Provide ground cable of one of the following:
      a. Southwire Corporation.

b. Service Wire Corporation.
c. Encore Wire Company.

B. Ground Rods:
1. Material: Copperclad rigid steel rods, 3/4-inch diameter, ten feet long.
2. Manufacturer: Provide ground rods by one of the following:
a. ERICO.
b. A.B. Chance Company.
c. South Atlantic, L.L.C.
d. Harger.

C. Grounding Connectors:
1. Material: Pressure connectors shall be copper alloy castings, designed specifically for the items to be connected, and assembled with Durium or silicone bronze bolts, nuts and washers. Welded connections shall be by exothermic process utilizing molds, cartridges and hardware designed specifically for the connection to be made.
2. Product and Manufacturer: Provide grounding connectors of one of the following:
a. Pressure Connectors:
1) O.Z./Gedney, Division of General Signal Corporation.
2) Burndy Corporation.
b. Welded Connections:
1) Cadweld by Erico Products, Incorporated.
2) Therm-O-Weld by Burndy Corporation.

D. Concrete Boxes:
1. Material: High density reinforced concrete box with non-settling shoulders positioned to maintain grade and facilitate back filling with steel checker plate screw down cover.
2. Size:
a. Outside Locations: 15” x 22” minimum.
b. Inside Locations: 10” x 17” minimum.
3. Product and Manufacturer: Provide box assembly from one of the following:
a. Concrete Box:
1) Christy Concrete Products, Inc. Model #B1017.
2) Or Equal.
b. Steel Cover:
1) Christy Concrete Products, Inc. Model #B61JH labeled “GROUND”.
2) Or Equal.

PART 3 - EXECUTION

3.1 STRUCTURE GROUND SYSTEM

A. Provide ground grids as shown on the Drawings.

B. Install No. 4/0 AWG bare copper cable. Install the cable around the exterior perimeter of structures, minimum 2 feet-6 inches below grade, unless otherwise shown on the Drawings.

C. Install ground rods where shown on the Drawings. Install additional ground rods, if necessary, to attain a resistance to ground of less than twenty five (25) ohms for each ground grid.

D. For structures with steel columns, install 4/0 AWG ground cable. Install cable from grid to each column around the perimeter of the structure. Connect cable to steel using exothermic welds.

E. Connect grids to a continuous underground water pipe system, when practical.

F. Provide concrete ground test wells for measuring the ground resistance of each separately derived power source, including generators, prior to terminating in equipment. Provide 12" ground conductor slack loop in each well. Route ground conductor from test well to equipment in PVC conduit.

G. Weld all buried connections. Test points connections shall utilize pressure connectors.

3.2 EQUIPMENT GROUNDING

A. Ground all electrical equipment in compliance with the National Electrical Code and the City of Phoenix Electrical Code.

B. Equipment grounding conductors shall be bare stranded copper cable of adequate size installed in metal conduit where necessary for mechanical protection. Ground conductors, pulled into conduits with non-grounded conductors, shall be insulated. Insulation shall be green.

C. Panel Grounding:
   1) A minimum size of 4/0 AWG bare stranded copper cable shall be installed between the ground grid and the panel enclosure grounding lug. The mounting frame for panels shall be grounded to the ground grid.
   2) A minimum size of 6 AWG insulated green stranded copper cable shall be installed between the ground grid and the isolated DC Ground Bus located on the enclosure sub-panel. This ground shall be installed in all panels that provide an isolated DC Ground Bus.

D. A separate green insulated ground conductor sized per conduit schedule as shown on DRAWINGS or NEC requirements shall be pulled into conduits and connected utilizing grounding conduit bushings.

E. Connect ground cable to piping by welding or brazing. Use copper bonding jumpers on all gasketed joints.

F. Connect ground cable to equipment by means of lug compressed on cable end. Bolt lug to equipment frame using holes or terminals provided on equipment specifically for grounding. Do not install with hold down bolts. Where grounding provisions are not included, drill suitable holes in locations designated by ENGINEER.

G. Connect to motors by bolting directly to motor frames, not to sole plates or supporting structures.

H Connect to service water piping by means of copper clamps. Use copper bonding jumpers on gasketed joints.

I. Scrape bolted surfaces clean and coat with a conductive oxide- resistant compound.

J. Test all system grounding conductors for continuity of connection and electrical equipment. Provide in the final report a statement on equipment that was tested and document any discrepancies noted during the tests.

++ END OF SECTION ++

SECTION 16121

CONTROL (INSTRUMENTATION) CABLE

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish and install instrumentation, telephone cables, security system cables, serial communication cables, and Ethernet cables.
   2. The types of cable include the following:
      a. Single Conductor Control Cable
      b. Shielded Cable
      c. Unshielded Cable
      d. Telephone Cable
      e. Intercom and Paging System Cable
      f. Security Cable
      g. Category 6 Unshielded Twisted Pair (UTP) Cable (Ethernet Cable)
      h. RS-485 Cable
      i. DeviceNet

1.2 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Manufacturer's technical information for instrumentation cable proposed for use.
   2. Manufacturer’s technical information for telephone cable and underground splicing for approval by the City of Phoenix, Information Technology Department.
   3. Manufacturer’s technical information for serial and Ethernet cable in accordance with the requirements of these specification and as specified on drawings.

PART 2 - PRODUCTS

2.1 MATERIALS

A. 120 Volt or less Single Conductor Control Cables see Section 16122.2.1.A

B. Single Shielded Pair Cable:
   1. Tinned copper, nineteen strand, PVC insulated conductors, No. 16 AWG minimum, twisted with aluminum-polyester shield, stranded tinned 16 AWG

copper drain wire and PVC black or gray outer jacket. Wire conductor colors shall be black (-neg) and red (+pos). 600 Volt Tray Cable (TC) rated.

2. Product and Manufacturer: Provide one of the following:
   a. Belden Company (No. 9342).
   b. Okonite Company.
   c. Dekoron Wire and Cable Company.

G. Cable Terminals:
1. Provide ferule compression fittings or UL listed fork type copper compression terminals with nylon insulation for termination of cable at all terminal blocks.
2. For Panels provided under 17260, see Section 17260 - Field Wire Termination for termination methods, product and manufacturer.
3. Product and Manufacturer: Provide one of the following:
   a. T&B Sta-Kon.
   b. Burndy Insulug.

H. Cable/Wire Markers:
1. Provide only heat shrinkage type cable/wire identification, which shall be type-written.
2. Wire number shall include the conduit number and be a consecutive number based on the number of wires in a conduit, starting with number 1; example C18J – 1, where as C18J is the conduit number and 1 is the first wire. If ten wires are in a conduit, the numbering would be C18J-1 through C18J-10. No two wires are to have the same number.
3. Product and Manufacturer: Provide the following:
   a. W.H. Brady Company. (Part # PSPT-187 for a single conductor)
   b. W.H. Brady Company. (Part # PSPT-500-1W for a twisted pair shielded cable)
   c. Or equal

J. Category 6 Unshielded Twisted Pair (UTP) Cable:
1. Category 6, Four-pair, balanced- twisted pair cable, No. 23 AWG solid copper. Must comply with NEMA WC 66/ICEA S-116-732 and TIA-568-D for Category 6 cables.
2. Cable Rating: As applicable for the application.
3. Thermoplastic Jacket, Blue.
4. Required performance Characteristics:
   a. 1-250 MHz frequency range
   b. 100 Ohm impedance
   c. Min. attenuation 19.9dB
   d. Min. Near-end Crosstalk (NEXT) 44.3dB at 100MHz
   e. Min. Power Sum Near-end Crosstalk (PSNEXT) 42.3dB at 100MHz
   f. Min. Attenuation to Crosstalk Ratio, Far-end (ACRF) 27.8dB at 100MHz
   g. Min. Power Sum Attenuation to crosstalk ratio, Far-end (PSACRF) 24.8dB at 100MHz
   h. Min. return loss 20.1dB at 100MHz

i. Max. delay skew 45 ns
j. Max. propagation delay 540 ns

5. Ethernet patch cables shall be Category 6, four-pair, pre-wired and terminated, with RJ-45 connectors and lever protecting boot.

K. RS-485 Cable:
1. Standard Cable: NFPA 70, Type CMG
a. Tinned copper conductors, No. 22 AWG seven strand, twisted shielded pair. Polyethylene conductor insulation with PVC insulation with PVC jacket, UL 1685 compliant (flame resistance).
2. Plenum-Rated Cable: NFPA 70, Type CMP
a. Tinned copper conductors, No. 22 AWG seven strand, twisted shielded pair. Fluorinated ethylene propylene (FEP) conductor insulation with FEP jacket, NFPA 262 compliant (flame resistance).

L. DeviceNet Cable:
1. Product and Manufacturer: Provide the following:
a. Belden Company (No. 7896A).

PART 3 - EXECUTION

3.1 INSTALLATION

A. Separation Requirements:
1. Instrumentation Cables shall not be installed within the same conduits, raceways or cable trays with cables identified in Sections 16122, 16123 and 16124.
2. Telephone Cables are to be routed separately from other cables.
3. Intercom and Paging System Cables are to be routed separately from other cables.
4. Fire Detection or Protection System Cables are to be routed separately from other cables.
5. Security System Cables are to be routed separately from other cables unless noted on the drawings.
6. Straight through Ethernet cables shall be wired using the TIA/EIA-568-B.1 T568-B standard for both connectors. Crossover Ethernet cables shall be wired using the TIA/EIA-568-B.1 T568-A standard for one connector and the T568-B standard for the opposite end.

Connector Pin	568A Wiring Conductor	568B Wiring Conductor
1 2	White/Green Green	White/Orange Orange
3 6	White/Orange Orange	White/Green Green

4 5	Blue White/Blue	Blue White/Blue
7 8	White/Brown Brown	White/Brown Brown

7. Additional separation requirements:
   a. Class 1 Control circuits (limited to 120 V, see NEC Section 725 Parts I & II for Class 1 Circuits) are to be routed separately from other cables. (Lights and starter circuits)
   b. Class 2 Control circuits (limited current and less than 50 V, see NEC Section 725 Parts I & III for Class 2 Circuits) are to be routed separately from other cables. (Analog signal, digital communications, Discrete Inputs and Outputs)
   c. Class 3 Control circuits (limited current and less than 120 V, see NEC Section 725 Parts I & III for Class 3 Circuits) are to be routed separately from other cables. (Discrete Inputs to and Outputs from OPTO 22 modules to or from contacts and interposing relay coils.)

B. Install all cables complete with proper identification and terminations at both ends. Cable outer installation shall be dressed at the end of the cables with heat shrink tubing prior to terminations. Utilizing electrical tape is not allowed for dressing.

C. Ground shield of shielded cables at one end only and as recommended by instrument manufacturer. When multiple shielded cables are terminated on a designated analog terminal strip an insulated green with yellow strip wire is used to jumper between the shield terminals and at the end of the terminal strip terminate the shields to the isolated DC ground bar mounted in the panel.

D. Terminate stranded conductors with pre-insulated crimp type spade or barrel compression fitting terminals properly sized to fit fastening device and wire size.

E. Install and terminate vendor furnished cable in accordance with vendor equipment requirements.

F. Coordinate the installation and termination of the telephone cables with the City of Phoenix, Information Technology Department.

G. Install in conformance with the National Electrical Code and the City of Phoenix Electrical Code.

H. Identification:
   1. Each cable and conductor shall be identified in each pull box and manhole with identification markers, which shall include the conduit number and/or cable number. The markers shall be self-laminating vinyl on white background and shall be printed using a Brady "XC Plus" printer or equal.

3.2 TESTING

A. Test all 600-volt wiring in accordance with the requirements of Section 16122, 600 Volt Cable.

B. Test shielded instrumentation cable shields with an ohmmeter for continuity along the full length of the cable and for shield continuity to ground. The tests shall be witness by the OWNER and ENGINEER.

C. Connect shielded instrumentation cables to a calibrated 4 to 20 mADC signal transmitter and receiver. Test at 4, 12 and 20 milliamp transmitter settings.

D. Telephone cables shall be tested in accordance with and in the presence of the City of Phoenix, Information Technology Department. A written proposed schedule shall be submitted a minimum of seven days prior to the testing of each telephone cable for inspection coordination.

E. After network cabling has been installed, Balanced Twisted Pair Cables (Ethernet cables) shall be tested using a network cable tester that is compatible with Category 6 cabling. Testing equipment shall have a current calibration certificate. Each cable shall be tested for open pair, shorted pairs, crossed pairs, reversed pairs, split pairs, and compliance with performance characteristics defined in this specification. All Ethernet cable installed shall be tested and CERTIFIED to meet TIA-568-D standards. The test equipment used shall be an advanced cable certifier that meets the TIA testing certification requirements. Ethernet cable testing and certification shall be witnessed by the ENGINEER. A report with all required TIA cable certification requirements shall be provided for all Ethernet cables tested.

++ END OF SECTION ++

SECTION 16122
600 VOLT CABLE

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish and install 600 volt cable.
   2. The types of cable required include the following:
      a. Insulated cable for installation in raceways.
      b. Cable for installation in trays.
      c. Direct burial cable.
      d. Direct burial cable duct.

1.2 QUALITY ASSURANCE

A. Requirements of Regulatory Agencies: Comply with applicable provisions of Regulatory Agencies below and others having jurisdiction:
   1. Codes: Install cable in accordance with the Phoenix Electrical Code and applicable local codes.
   2. Tests by Independent Regulatory Agencies: Cable shall bear the label of the Underwriters' Laboratories, Inc.

B. Reference Standards: Comply with applicable provisions and recommendations of the following, except where otherwise shown or specified:
   1. ASTM B 3, Soft or Annealed Copper Wire.
   2. ASTM B 8, Concentric-Lay-Stranded Copper Conductors, Hard, Medium-hard or Soft.
   3. ICEA S-66-524, Cross-linked-thermosetting- polyethylene-insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
   4. National Electrical Code (NEC) current adoption.
   5. City of Phoenix – Amendments to the National Electrical Code.
   6. UL Standard No. 44, Wires and Cables, Rubber-Insulated.
   7. UL Standard No. 83, Wires and Cables, Thermoplastic-Insulated.
   8. IEEE Standard 971.

C. Factory Production Tests:
   1. All wire and cable shall be factory tested in accordance with the requirements of Underwriters' Laboratories.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:

1. Manufacturer's literature, specifications, and engineering data for 600 volt insulated cable proposed for use.
2. Manufacturer's literature for cable markers.

B. Test Records: Submit for review copies of written records of field insulation resistance test results.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Insulated Cable In Raceways:
1. Material: Single conductor copper cable conforming to ASTM B 3 and B 8 with flame-retardant, moisture and heat resistant cross-linked polyethylene or thermoplastic insulation rated 90°C in dry locations and 75°C in wet locations and listed by UL as Type XHHW-2. Multi conductor cable shall only be utilized in cable tray applications or unless specified on drawings.
2. Application: Use Type XHHW-2 for all sizes, unless otherwise indicated.
3. Wire Sizes: Not smaller than No. 12 AWG for power and lighting and No. 14 AWG for 120 volt control circuits
4. Stranding: All 600 volt cable shall be stranded.
5. Product and Manufacturer: Provide one of the following:
   a. Okonite Company
   b. Encore Wire Corporation
   c. The Southwire Company
   d. Service Wire Company
   e. General Cable

B. Cable for Installation in Trays:
1. Material: Factory assembled cable, multi-conductor as required by the Drawings, Type XHHW-2 bearing the UL label, Type TC and specifically approved for installation in cable trays and meeting the flame test requirements of IEEE 1202.
2. For control circuits provide a minimum number of spare three (3) conductors per cable
3. Product and Manufacturer: Provide one of the following:
   a. The Southwire Company.
   b. The Okonite Company.
   c. Service Wire

C. Direct Burial Cable:
1. Single or multiconductor, stranded copper conductors, 60-mils butadiene styrene or ethylene propylene insulation, overall jacket of neoprene or PVC. Rated at 600 volts.
2. Product and Manufacturer: Provide one of the following:

a. The Okonite Company.
b. American Insulated Wire Corporation.

D. Direct Burial Cable Duct:
1. Material: Multi conductor stranded copper cables; 600 volt cross-linked polyethylene insulated, factory assembled in a coilable, medium density polyethylene duct suitable for direct burial in earth for operation at a maximum conductor temperature of 90°C.
2. Product and Manufacturer: Provide one of the following:
a. Cablecon by Integral Corporation.
b. Tamaqua Duct System by Tamaqua Cable Products Corporation.

E. Cable Connectors, Solderless Type:
1. For wire sizes up to and including No. 6 AWG, use compression type. Alarm and control wire shall be terminated using forked type connectors at terminals. If terminal block is crimp type, then the wire shall be terminated with a crimped ferrule or solder dipped.
2. Product and Manufacturer: Provide one of the following:
a. Phoenix Contact – Clipline
b. Thomas & Betts
c. Weidmuller
b. Burndy Hylug.
3. For wire sizes No. 4 AWG and above, use either compression type or bolted type with tinned-plated contact faces.
4. For wire sizes No. 250 kcmil and larger, use connectors with at least two cable clamping elements or compression indents and provision for at least two bolts for joining to apparatus terminal.
5. Properly size connectors to fit fastening device and wire size.

F. Cable Splices:
1. For wire sizes No. 8 AWG and larger, splices shall be made up with compression type copper splice fittings. Splices shall be taped and covered with materials recommended by the cable manufacturers, to provide insulation equal to that on the conductors.
2. For wire sizes No. 10 AWG and smaller, splices may be made up with preinsulated spring connectors.
3. For wet locations, splices shall be waterproofed. Compression type splices shall be waterproofed by a sealant-filled, thick wall, heat shrinkable, thermosetting tubing or by pouring a thermosetting resin into a mold that surrounds the joined conductor. Spring connector splices shall be waterproofed with a sealant-filler.

4. Product and Manufacturer: Provide one of the following:
a. Compression-Type Splices:
1) Burndy Hylink.
2) T&B Color-Keyed Compression Connectors.
b. Spring Connectors:

1) Buchanan B-Cap.
2) T&B Wire Connector.

G. Cable/Wire Markers:
1. Provide only heat shrinkage type cable/wire identification, which shall be type-written.
2. Wire number shall include the conduit number and be a consecutive number based on the number of wires in a conduit, starting with number 1; example C18J – 1, where as C18J is the conduit number and 1 is the first wire. If ten wires are in a conduit, the numbering would be C18J-1 through C18J-10. No two wires are to have the same number.
3. Product and Manufacturer: Provide the following:
a. By W.H. Brady Company. (Part # PSPT-187 for a single conductor)
b. Or Approved Equal

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install all cables complete with proper identification and terminations at both ends. Check and correct for proper phase sequence and proper motor rotation.

B. Pulling:
1. Use insulating types of pulling compounds containing no mineral oil.
2. Pulling tension shall be within the limits recommended by the wire and cable manufacturer.
3. Use a dynamometer where mechanical means are used.
4. Cut off section subject to mechanical means.

C. Bending Radius: Limit to a minimum of six times cable overall diameter.

D. Slack: Provide maximum slack at all terminal points.

E. Splices:
1. Where possible, install cable continuous, without splice, from termination to termination.
2. Where required, splice where shown on the Drawings or as approved by the ENGINEER and also where required for cable installation. All splices below grade, in manholes, handholes and wet locations shall be waterproofed.
3. Splices are not allowed in conduits.
4. All splices shall be pre-approved by ENGINEER.

F. Identification:
1. Each cable and conductor shall be identified in each pull box and manhole with identification markers, which shall include the conduit number and/or cable

number. The markers shall be self-laminating vinyl on white background and shall be printed using a Brady "Tagus T300" printer or equal.

G. Phase Identification/Color Coding:
   1. All three phase circuits shall be identified, which shall include the conduit number and phase, at switchgear, motor control centers, manholes (5 KV), cables and panelboards as "PHASE A"," PHASE B", and "PHASE C". All conductors not identified with a tag number shall be identified with a tag indicating the source.
   2. Three phase 480 volt systems shall be color coded as follows:
      a. Phase A - Brown.
      b. Phase B - Orange.
      c. Phase C - Yellow.
      d. Neutral (if applicable) - White.
   3. Single phase, 120/240 volt circuits shall be color coded as follows:
      a. Phase A - Black.
      b. Phase B - Red.
      c. Neutral - White.
   4. Three phase, 208 volt systems shall be color coded as follows:
      a. Phase A - Black.
      b. Phase B - Red.
      c. Phase C - Blue.
      d. Neutral - White.
   5. No. 6 AWG and Smaller: Provide colored conductors.
   6. No. 4 AWG and Larger: Apply general purpose, flame retardant tape at each end, wrapped in overlapping turns to cover an area of at least 2-inches.
   7. All field wiring color shall be black unless otherwise noted.

3.2 TESTING

A. Test each electrical circuit after permanent cables are in place to demonstrate that the circuit and connected equipment perform satisfactorily and that they are free from improper grounds and short circuits.

B. Individually test 600 volt cable mechanical connections after installation and before they are put in service with a calibrated torque wrench. Values shall be in accordance with manufacturers' recommendations.

C. Individually test 600 volt cables for insulation resistance between phases and from each phase to ground. Test after cables are installed and before they are put in service with a Megger whose rating is suitable for the tested circuit. Tests shall meet with the applicable specifications of IPCEA S-66-524 and NEMA WC7-1971. Tests shall be witnessed by the ENGINEER.

D. The insulation resistance for any given conductor shall not be less than the value recommended by the IPCEA or a minimum of one megohm for 600 volt and less

service, if not IPCEA listed. Any cable not conforming to the recommended value or which fails when tested under full load conditions shall be replaced with a new cable for the full length.

E. Install in accordance with the National Electrical Code and the City of Phoenix Electrical Code.

++ END OF SECTION ++

SECTION 16131

PVC COATED RIGID METAL CONDUIT, RIGID NONMETALLIC CONDUIT, ELECTRICAL METALLIC TUBING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
1. Provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish and install conduit and fittings to provide complete, coordinated and grounded raceway systems.
2. Conduit routings for various systems within buildings and other areas may not be shown on the Drawings. Responsibility to establish single line, riser and interconnection diagrams and any other related information shown on the Drawings, belongs to CONTRACTOR. Provide for the proper installation of all conduits for each system. Submit conduit routing and tagging meeting all specifications of Submittals Section 1.3-A and Section 2.1-G below to Engineer/Owner for review and approval prior to construction.
3. The following types and installation methods shall conform to the following:
   a. Polyvinyl Chloride (PVC) Coated Rigid Metal Conduit (NEC Article 344)
      1) Corrosive areas.
      2) For exposed indoor conduit runs.
      3) For exposed conduit runs in all outdoor areas.
      4) For all underground bends (horizontal and vertical) in duct banks that are 45º or more.
      5) For non-encased underground conduit.
      6) For VFD to motor runs.
      7) For conduit lighting runs for single conduits non-encased (an alternative to Rigid Nonmetallic Conduit (RNC) encased)
   b. Rigid Nonmetallic Conduit (RNC): Schedule 40 PVC conduit. (NEC Article 352)
      1) For masonry walls.
      2) For concrete encased duct bank runs.
      3) For conduits embedded in structural concrete slabs.
      4) For under structural slabs.
   c. Electrical Metallic Tubing (EMT) (NEC Article 358):
      1) For metal stud walls where shown on CONTRACT DRAWINGS.
      2) For above ceilings where shown on CONTRACT DRAWINGS.
      3) EMT is not to be used in buildings which have PVC coated rigid metal conduit systems.

B. Coordination:
   1. Conduit runs shown are diagrammatic. Coordinate conduit installation with piping, ductwork, lighting fixtures and other systems and equipment and locate so as to avoid interferences.
   2. For conduits to be embedded in concrete slabs, confirm adequate slab thickness and coordinate location of conduits with placement of reinforcing steel, water stops and expansion joints.

1.2 QUALITY ASSURANCE

A. Reference Standards: Comply with applicable provisions and recommendations of the following, except where otherwise shown or specified.
   1. National Electrical Code (NEC) current adoption.
   2. UL Standard No. 6, Rigid Metal Electrical Conduit.
   3. UL Standard No. 651, Schedule 40 and 80 PVC Conduit.
   4. ANSI C80.4, Fittings for Rigid Metal Conduit and Electrical Metal Tubing
   5. NEMA TC2, Electrical Plastic Tubing, Conduit and Fittings.
   6. NEMA TC3, PVC Fittings for Use with Rigid PVC Conduit and Tubing.
   7. NEMA RN 1, Polyvinyl Chloride (PVC) Externally Coated Rigid Metal Conduit and Intermediate Metal Conduit
   8. TIA-569-B, Commercial Building Standard for Telecommunications Pathways and Spaces
   9. BICSI Customer-Owned Outside Plant Design Manual

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Manufacturer’s catalog cuts for the conduit, fittings, supports, conduit identification tags, orange electrical ID tape, and warning ribbon proposed for use. Provide engraved samples of conduit identification tags.
   2. Construction details of conduit racks and other conduit support systems.
   3. Layout drawings showing proposed routing of exposed conduits, conduits embedded in structural concrete and conduits directly buried in earth. Drawings shall show locations of intermediate termination panels (ITP's), pull boxes and penetrations in walls and floor slabs. Drawings of embedded conduits shall include cross-sections showing the thickness of the concrete slabs and the locations of conduits with respect to reinforcing steel and waterstops. Tag conduits per conduit schedule shown on drawings.
   4. Drawing shall be electronically produced to maintain quality and clarity of presentation when re-produced, even when reduced to half size (11” x 17”).
   5. Provide manufacturer’s proof of certification for PVC coated rigid metal conduit for all installer’s supervisors.

B. Record Drawings: Show the actual routing of exposed and concealed conduit runs on the Record Drawings conforming to the requirements of Section 01782-1.1, Record Documents.

PART 2 – PRODUCTS

2.1 MATERIALS - CONDUIT AND CONDUIT FITTINGS

A. PVC Coated Rigid Metal Conduit:
   1. Conduit, Elbows and Couplings:
      a. Material: Rigid, heavy wall, mild steel, interior coating of 2-mil thick urethane, tapered threads, carefully reamed ends, 3/4-inch NPS minimum size for exposed, 1 inch for embedded, encased, or otherwise inaccessible, with a factory exterior coating of 40-mil thick polyvinyl chloride.
      b. Color: All PVC coated materials shall be standard dark gray.
      c. Tools: Power drives, chucks, z-wrenches, vises, and cutting or bending tools shall follow recommendations for tooling in manufacturer's installation guide. Use touch-up compounds recommended by the manufacturer for repair of minor damage to interior urethane or exterior PVC factory coatings.
      d. Manufacturer: Provide conduit and fittings of one of the following:
         1) Robroy Industries, "Perma-Cote".
         2) Robroy Industries, "Plasti-Bond".
         3) OCAL Inc.
   2. Fittings and Outlet Bodies:
      a. Material and Construction: Cast gray iron alloy, cast malleable iron bodies and covers with a factory coating of 40-mil thick polyvinyl chloride, an interior coating of 2-mil thick urethane and Form 7 tongue-in-groove V-seal gasket on sizes ½" through 2". Conduit or fittings having areas with thin or no coating shall be unacceptable. Do not use "LB" fittings for conduit sizes of 1¼" or larger. Use type "LBD" fittings wherever the use of fittings for conduit sizes of 1¼" or larger is unavoidable. All units shall be threaded type with five full threads. Material shall conform to ANSI C80.4.
      b. Use: Provide conduit fittings and outlet bodies in all corrosive locations.
      c. Manufacturer: Provide PVC coated conduit fittings and outlet bodies of one of the following:
         1) Robroy Industries, "Perma-Cote".
         2) Robroy Industries, "Plasti-Bond".
         3) OCAL Inc.
   3. Conduit Hubs:
      a. Material: Threaded conduit hub, vibration proof, weatherproof with captive O-ring seal, zinc metal with insulated throat and factory coating of 40-mil thick polyvinyl chloride and smooth urethane interior coating.
      b. Use: Provide for all PVC coated conduit terminations to boxes, cabinets and other enclosures located in all areas.

c. Locknuts are not allowed. Use hubs only.
d. Manufacturer: Provide one of the following:
1) Robroy Industries, “Perma-Cote”.
2) Robroy Industries, “Plasti-Bond”.
3) OCAL Inc.

B Rigid Nonmetallic Conduit:
1. PVC Plastic Conduit:
a. Conduit Material: Schedule 40 PVC plastic, 90°C rated, conforming to NEMA TC-2 and UL No. 651.
b. Fittings: Elbows, bodies, terminations, expansions and fasteners of same material and manufacturer as base conduit. Materials shall conform to NEMA TC-3 and UL No 514.
c. Provide cement and primer by same manufacturer as base conduit.
d. Manufacturer: Provide conduit and fittings of one of the following:
1) PW Eagle
2) Prime Electrical Products
3) Cantex

C. Electrical Metallic Tubing:
1. Elbows, Fittings, and Couplings:
a. Material: Rigid-type mild steel, galvanized (zinc) exterior, organic lubricated interior, threadless 3/4-inch NPS minimum size.
b. Couplings and connections: Compression or threaded type only. Set screw type shall not be permitted.
c. Elbows: Factory formed of same material specified for EMT conduit.
d. Certifications: Material shall conform to UL-797, ANSI C80.3. Conduit, elbows, couplings, etc. shall bear UL listing and manufacturer’s name.
e. Use of EMT type raceway systems shall only be permitted where specified in Paragraph 1.1.A.4.c, above.
f. Manufacturer: Provide EMT conduit, elbows, fittings and couplings of one of the following:
1) Allied Tube and Conduit.
2) LTV Steel Tubular Products Company.
c) Wheatland Tube Company.

2.2 MATERIALS - MISCELLANEOUS FITTINGS

A. Conduit Bushings:
1. Insulated Bushings: Malleable iron body with plastic liner, threaded type with steel clamping screw. Provide with bronze grounding lug, as required.
2. Use: Provide for all conduit terminations to boxes, cabinets, other enclosures and raceways not requiring a hub.
3. Manufacturer: Provide one of the following:
a. O-Z/Gedney.
b. Appleton Electric Company.

c. Thomas and Betts.

B. Conduit Tags:
1. Tag all conduits at the ends and in all intermediate boxes, chambers, hand holes and other enclosures.

2. Conduit tags shall be yellow, 1-1/2-inch diameter, round, aluminum tags, laser engraved or standard engraving with the conduit number as shown on the Conduit and Cable Schedule. Punched or stamped lettering is not allowed. Font shall be 1/4-inch Arial or Helvetica. The conduit tags shall be manufactured by Brady, Catalog No. 49900, Or Equal.
3. Each tag shall be attached with nylon-coated 48-mil stainless steel wire and fasteners, as manufactured by Brady, Catalog No. 38091, and zinc wire clamps, double ferrule design, as manufactured by Brady Catalog No. 38090 to secure the stainless steel wire. Where this method is not practical, fasten to the adjacent masonry by means of expansion bolts.

C. Warning Ribbon:
1. Over all underground duct banks and direct cables, install warning ribbon approximately 12-inches below finished grade and centered on direct buried cables, electrical ductbanks and conduits without ductbank encasement. Provide 6-inch wide, 4-mil thickness underground metallic-lined marking tape with red polyethylene film on top and with clear polyethylene film on the bottom. The tape shall be permanently imprinted with "CAUTION BURIED ELECTRIC LINE BELOW".
2. Manufacturers: Provide one of the following:
a. Brady "Identoline"; Services and Materials "Buried Underground Tape"
b. Somerset (Thomas & Betts) "Protect-A-Line"

PART 3 – EXECUTION

3.1 INSTALLATION

A. Install in conformance of NEC, Articles 344, 352 and 358. Cap all conduits, ducts and raceways during construction to protect from debris entering and blocking the circuit installation. Conduits containing circuits less than 50VAC or 50VDC shall be separated from other conduits by a minimum of 12 inches.

B. Supports:
1. Rigidly support conduits by clamps, hangers or strut channels.
2. Support single conduits by means of one-hole pipe clamps in combination with one-screw back plates, to raise conduits from the support surface. Support multiple runs of conduits on trapeze type hangers with Type 316 Stainless Steel horizontal members and Type 316 Stainless Steel threaded

hanger rods, Kindorff or equal. Rods shall be not less than 3/8-inch diameter.

3. PVC coated rigid metal conduit runs, beam clamps, U-bolts, pipe straps, clamp back spacers, clamp hangers and supports shall have a factory applied PVC coating or be stainless steel. Hardware shall be Type 316 Stainless Steel.
4. Right angle beam clamps and U bolts shall be specially formed and sized to snugly fit the outside diameter of the coated conduit.

C. Fastenings: Fasten raceway systems rigidly and neatly to supporting structures by the following methods:
   1. To Wood: Type 316 Stainless Steel wood screws.
   2. To Hollow Masonry Units: Type 316 Stainless Steel toggle bolts.
   3. To Brick Masonry: Type 316 Stainless Steel Price expansion bolts, or equal.
   4. To Concrete: Refer to spec section 05051.
   5. To Steel: Type 316 stainless steel welded threaded studs, beam clamps or bolts with lock-washers or locknuts.

D. PVC Coated Rigid Metal Exposed Conduit:
   1. Install in strict accordance with manufacturer's recommendations and installation manual. Installers shall be certified by the manufacturer before installation begins.
   2. Install with manufacturer's installation tools and compounds to prevent damage to the PVC coating.
   3. Repair minor damage to interior urethane and exterior PVC coating with manufacturers recommended touch-up compound.
   4. Install parallel or perpendicular to structural members or walls.
   5. Wherever possible, run in groups. Provide conduit racks of suitable width, length and height and arranged to suit field conditions. Provide support at manufacturer's recommended distances, or at every ten feet minimum.
   6. Install on structural members in protected locations.
   7. Locate clear of interferences.
   8. Maintain 6-inches from hot fluid lines and 1/4-inch from walls.
   9. Install vertical runs plumb. Unsecured drop length not to exceed 12 feet.
   10. Provide necessary reducers where equipment furnished cannot accept 3/4-inch conduit.

E. Conduit Embedded in Structural Concrete:
   1. Separation: Three times outer diameter of larger conduit center to center.
   2. Minimum Slab Thickness: Confirm that concrete slab thickness is sufficient for embedding conduits.
      a. For embedding conduit sizes up to 1-1/2 inches, the minimum slab thickness shall be 7-inches plus the outer diameter of the conduit or conduits, where conduits cross.
      b. For embedding conduits larger than 1-1/2 inches, the minimum slab thickness shall be five times the outer diameter of the conduit where

conduits do not cross and six times the outer diameter of the larger conduit where conduits do cross.

3. Concrete shall have a minimum 28-day compressive strength of 2,000 PSI. Concrete used for ductbanks shall be Type 2 with red color added as specified in "Cast-in-Place Concrete" Section 03300.
4. Run conduits in center of slab, where applicable.
5. Run conduits in spacers to maintain recommended minimum, even spacing.
6. Run conduits above waterstops.
7. Before concrete is placed, make the necessary location measurements of the conduits to be embedded so that the information is available to prepare Record Drawings.
8. All conduits entering or exiting concrete shall be PVC coated galvanized rigid metal, for a minimum of 12-inches from the concrete edge.

F. Underground Conduits that are non-encased: PVC coated rigid metal conduits.
1. Install individual underground conduits a minimum of 24-inches below grade, unless otherwise shown on the Drawings or as required to avoid existing obstructions.
2. Perform all excavation, bedding, backfilling and surface restoration including pavement replacement, where required.
3. Install warning ribbon 12-inches below finished grade over all conduits.
4. Make conduit connections watertight by applying PVC touch-up compound at the sealing sleeve joints.

G. Empty Conduits:
1. Spare conduits shall be cleaned, swabbed, and mandreled to verify viability for future use.
2. Install a true tape or mule tape in each empty conduit and cap conduits not terminating in boxes with permanent fittings designed for the purpose. Pulling rope or tape shall be constructed of polyester and factory lubricated. Nylon is not allowed.
3. Identify each empty conduit with a conduit tag conforming to the requirements of Paragraph 2.1.G., above, showing the conduit number shown on the Drawings.

H. Field Bends: Use manufacturer supplied field bends whenever possible. No indentations. Diameter of conduit shall not vary more than 15 percent at any bend. Maximum total amount of bends shall not exceed 270°.
Length of run between manholes shall be limited to:
1. 300 feet with 270° in bends.
2. 600 feet with 180° in bends.
3. 1000 feet with 90° in bends.

I. Joints:
1. Make joints tight and ground thoroughly.
2. Use standard tapered pipe threads for conduit and fittings.
3. Cut conduit ends square and ream to prevent damage to wire and cable.

4. Use a degreasing spray to thoroughly clean field cut threads, and internal reams to insure the touch-up compound will adhere to the unprotected metal.
5. Apply urethane touch-up compound to all joints, field cut threads, and internal reams before assembly for corrosion protection and visible identification of proper installation.
6. Use full threaded couplings. Split couplings not permitted.
7. During installation, install with manufacturer's installation tools to prevent damage to PVC coating. Replace conduit with wrench marks.

J. Moisture Protection:
1. Plug or cap conduit ends at time of installation to prevent entrance of moisture or foreign materials.
2. Make underground and embedded conduit connections water-tight.
3. Through Wall Seals and Conduit Sealing Bushings: Install for all conduits passing through concrete slabs, floors, walls or concrete block walls.
   a. For conduits and cables in new construction and passing through exterior subsurface walls and exterior concrete walls, use Type WSK and WSCS through wall seals as manufactured by O-Z/Gedneyl.
   b. For conduits and cables in new construction and passing through concrete floors and floor slabs, use Type FSK and FSCS floor seals, as manufactured by O-Z/Gedney.
   c. For conduits passing through new exterior block walls or through core-drilled holes in existing exterior subsurface walls, exterior concrete walls, floor slabs and roof slabs, use Type CSMI sealing bushing at the inside of the structure and Type CSMC sealing bushing at the outside of the structure. Sealing bushings shall be as manufactured by O-Z/Gedney.
   d. For conduits passing through existing interior concrete walls or floors and interior block walls, provide CSMC or CSMI type sealing bushings as manufactured by O-Z/Gedneyl.
4. Drainage: Pay particular attention to drainage for conduit runs. Wherever possible, install conduit runs so as to drain to one end and away from buildings. Avoid pockets or depressions in conduit runs. Where conduits enter buildings below grade, seal inside of conduit to form a watertight seal around cables to prevent the entry of water into building.
   a. Product and Manufacturer: Provide one of the following:
      1) Type DUX - Duct Sealing Compound, as manufactured by O-Z/Gedney
      2) Type FST Foam Sealant, as manufactured by American Polywater Corp
5. Seal all conduit openings within control and instrumentation panels and distribution equipment with Type DUX - Duct Sealing Compound, as manufactured by O-Z/Gedney, to provide a water/bug-tight seal.
   a. Product and Manufacturer: Provide one of the following:
      1) Type DUX - Duct Sealing Compound, as manufactured by O-Z/Gedney

2) Type FST Foam Sealant, as manufactured by American Polywater Corp

K. Corrosion Protection:
1. Conduit Curb:
a. For conduits routed in concrete slabs or floors and stub-ups through the floor, provide a 2-inch high concrete curb, extending 2-inches from the outer surface of the conduit penetrating the floor, to prevent corrosion. For floor-mounted equipment, the concrete equipment base shall be in lieu of the concrete curb.
b. Conduit stub-ups shall be a 90 degree PVC coated rigid metal conduit elbow. PVC coated elbow shall extend slightly above the top of the concrete curb or equipment base. Should the elbow not reach this height, provide PVC coated conduit extension to accommodate requirements. Provide PVC coated coupling/fitting for transition from conduit in slab to elbow.
c. For conduits stubbing up and terminating at equipment enclosure mounted on a concrete equipment base, provide RNC stub-up and bell end.
d. For conduits stubbing up and extending to boxes, cabinets and other enclosures above the concrete curb in wet and dusty areas provide PVC coated conduit coupling/fittings between the PVC coated elbow and PVC coated rigid metal conduit for transition between the two conduit types.
e. For conduits stubbing up and extending to boxes, cabinets and other enclosures above the concrete curb or equipment base in corrosive areas, continue the conduit system with PVC coated rigid metal conduit.
f. Conduit into a protected base or equipment enclosure shall be RNC with RNC bell end.
2. Dissimilar Metals: Take every action to prevent the occurrence of electrolytic action between dissimilar metals

L. Reused Existing Conduits:
1. Pull rag swab through conduits to remove water and to clean conduit prior to installing new cable.
2. Repeat swabbing until all foreign material is removed.
3. Pull mandrel through conduit, if necessary, to remove obstructions.

M. Core drill for individual conduits passing through existing concrete slabs and walls. Obtain authorization from OWNER prior to core drilling. Prior to core drilling, drill sufficient number of small exploratory holes to establish that the area to be core drilled is free of existing embedded conduits. Seal spaces around conduit in accordance with Section 01723, Cutting and Patching, and the wall penetration details as shown on the Drawings.

N. Non-metallic Conduit:
1. Install in accordance with manufacturer’s recommendations.

2. Join sections in accordance with manufacturer's installation procedures for push-fit, bell and spigot type joints, if applicable, or with manufacturer's recommended cement and primer.
3. During installation provide expansion fittings for expansion and contraction to compensate for temperature variations. Expansion fittings shall be watertight and of the type suitable for direct burial.
4. Make transition to PVC coated galvanized rigid metal conduit before making turns into enclosures, cabinets, termination boxes, pull boxes, etc.
5. For expansion/deflection fittings as shown on CONTRACT DRAWINGS..

O. Wall Penetrations:
1. CONTRACTOR shall ensure conduits that penetrate walls allow for the maintenance of minimum bend radius during the installation of cable.
2. Submit shop drawings for approval for each wall penetration.

3.2 TESTING

A. Test conduits by pulling through each conduit a cylindrical mandrel not less than two pipe inside diameters long, having an outside diameter equal to 90 percent of the inside diameter of the conduit.

B. All conduits greater than 1.5 inches in size shall be swabbed and mandrel cleaned. This process shall be 100 percent witness inspected and each conduit inspection shall be identified and documented.

+ + END OF SECTION + +

SECTION 16132

FLEXIBLE CONDUITS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish and install flexible metallic conduit and fittings.

1.2 QUALITY ASSURANCE

A. Reference Standards: Comply with applicable provisions and recommendations of the following, except where otherwise shown or specified.
   1. Phoenix Electrical Code, Article 351, Liquid-Tight Flexible Metal Conduit.
   2. UL Standard No. 360, Liquid-Tight Flexible Steel Conduit.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Manufacturer's catalog cuts and technical information for flexible conduit and fittings proposed for use.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Flexible Conduit (Non-hazardous Areas):
   1. Material: Flexible galvanized steel core with smooth, abrasion resistant, liquid-tight, polyvinyl chloride cover and color to be black. Continuous copper ground built in for sizes 3/4-inch through 1-1/4-inch. Material shall be UL listed.
   2. Product and Manufacturer: Provide one of the following:
      a. Sealtite UA by Anaconda Metal Hose Division, Anaconda American Brass Company.
      b. Liquatite Type L.A. by Electric-Flex Company.
      c. Or equal.

B. Flexible Conduit (Class 1, Group D, Division 1, Hazardous Areas):
   1. Material: Flexible brass inner core with bronze outer braid. Steel, brass or bronze end fittings. Minimum of 12-inches in length.

2. Product and Manufacturer: Provide one of the following:
   a. Type ECGJH or ECLK by Crouse Hinds Company.
   b. Type EXGJH or EXLK by Appleton Electric Company.
   c. Or equal.

C. Flexible Conduit Fittings:
   1. Material and Construction: Malleable iron with zinc electroplating finish. Fittings shall adapt the conduit to standard threaded connections, shall have an inside diameter not less than that of the corresponding standard conduit size and shall be UL listed.
   2. Use: Provide on flexible conduit in non-hazardous and Class 1, Division 2 hazardous areas.
   3. Product and Manufacturer: Provide one of the following:
      a. Crouse-Hinds Company.
      b. Appleton Electric Company.
      c. Or equal.

D. PVC Coated Conduit Fittings:
   1. Material and Construction: Malleable iron with standard finish and 40-mil PVC exterior coating. Fittings shall adapt the conduit to standard threaded connections, shall have an inside diameter not less than that of the corresponding standard conduit size.
   2. Use: Provide on flexible conduit in areas designated as corrosive locations.
   3. Product and Manufacturer: Provide one of the following:
      a. Robroy Industries.
      b. Permacote Industries.
      c. OCAL Incorporated.
      d. Or equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install at motors, transformers and equipment which are subject to vibration or require movement for maintenance purposes. Provide necessary reducer where equipment furnished cannot accept 3/4-inch size flexible conduit. Limit flexible conduit length to three feet maximum.

B. Install in conformance with Phoenix Electrical Code requirements.

++ END OF SECTION ++

SECTION 16133

SEALING FITTINGS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish and install conduit sealing fittings.

1.2 QUALITY ASSURANCE

A. Reference Standards: Comply with applicable provisions and recommendations of the following, except where otherwise shown or specified:
   1. Phoenix Electrical Code, Article 500, Hazardous (Classified) Locations.
   2. UL Standard 886, Electrical Outlet Boxes and Fittings for Use in Hazardous Locations, Class 1, Groups A, B, C and D and Class II, Groups E, F and G.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Manufacturer's catalog cuts and technical information for sealing fittings proposed for use.
   2. Listing of locations where fittings are to be used.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Materials and Construction:
   1. Cast gray iron alloy or cast malleable iron or copper free aluminum bodies with zinc electroplate and lacquer or enamel finish.
   2. Ample opening with threaded closure for access to conduit hub for making dam.
   3. In corrosive locations, fittings shall include a factory applied 40-mil PVC coating.

B. Sealing fiber for forming the dam within the hub and the sealing compound shall be approved for use with the fittings furnished, and shall be products of the fitting manufacturer.

C. Product and Manufacturer: Provide the following:

1. ES Type by Eaton Crouse Hinds Company.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install for hazardous locations as required by Phoenix Electrical Code, and where as shown on the Drawings.

B. Select a fitting for the proper use in respect to the mounting position.

C. Use oversized fittings with reducing bushings when necessary to maintain cable fill requirements of the conduit system.

++ END OF SECTION ++

SECTION 16135

PULL BOXES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish and install pull boxes.

1.2 QUALITY ASSURANCE

A. Reference Standards: Comply with applicable provisions and recommendations of the following, except where otherwise shown or specified:
   1. Phoenix Electrical Code, Article 370, Outlet, Switch and Junction Boxes, and Fittings.
   2. UL Standard No. 50, Electrical Cabinets and Boxes.
   3. UL Standard No. 886, Electrical Outlet Boxes and Fittings for Use in Hazardous Locations.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Manufacturer's technical information for pull boxes proposed for use.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Pull Boxes: Provide boxes based upon location in accordance with NEMA requirements and as required for the area classification specified in Section 16050, General Provisions.
   1. Material and Construction:
      a. Cast gray iron alloy with hot-dip galvanized finish or cast malleable iron bodies and covers.
      b. Neoprene gaskets. Gaskets shall be of an approved type designed for the purpose. Improvised gaskets are not acceptable.
      c. Stainless steel cover bolts.
      d. External mounting lugs.
      e. Drilled and tapped conduit holes.
      f. Boxes where conduits enter a building below grade shall have 1/4-inch drain hole.

2. Product and Manufacturer: Provide pull boxes of one of the following:
   a. Appleton Electric Company.
   b. O-Z/Gedney Company.
   c. Hoffman Engineering Company.
   d. Or equal.
3. Large boxes not generally available in cast construction may be fabricated of copper-free aluminum alloy or Type 316 stainless steel as required by location.
4. Boxes for installation in areas classified as hazardous locations shall be explosion-proof and shall comply with the requirements of UL Standard No. 886.
5. For flush-mounted pullboxes in slabs or pavement, provide vehicular traffic-bearing covers, where shown on the Drawings.
6. Pull boxes embedded in concrete slabs shall be cast iron. Pull boxes located in wet, corrosive or outdoor areas shall be NEMA 4X, Type 316 stainless steel. All other areas shall be NEMA 12.
7. All boxes shall be identified in accordance with Section 16050, General Provisions.
8. All inside plant pull boxes used for communications, signal, or fiber optic cabling shall meet the requirements listed in table below:

Maximum Trade Size of Conduit (inches)	**Minimum Box Size (inches)**			**For Each Additional Conduit Increase Width (Inches)**
	Width	Length	Depth	
1	4	16	3	2
1.25	6	20	3	3
1.5	8	27	4	4
2	8	36	4	5
2.5	10	42	5	6
3	12	48	5	6
3.5	12	54	6	6
4	15	60	8	8

PART 3 - EXECUTION

3.1 INSTALLATION

A. Mount boxes so that sufficient access and working space is provided and maintain a minimum of 1/4-inch from walls.

B. Securely fasten boxes to walls or other structural surfaces on which they are mounted. Provide independent stainless steel or FRP supports where no walls or other structural surface exists. Do not locate pull boxes on handrails.

C. Install pull boxes where shown on the Drawings. In addition, install pull boxes in conduit runs containing more than three 90 degree bends and in runs exceeding 200 feet. For communications, signal, and fiber optic cabling conduit runs install pull boxes in runs containing more than two 90 degree bends and in runs exceeding 100 feet.

D. Provide removable, flame-retardant, insulating cable supports in all boxes with any dimension exceeding three feet.

E. Field apply PVC touch up to scratched PVC boxes damaged as a result of installation. All touch up work shall be in strict conformance with manufacturer's recommendations and instructions.

F. Size pull boxes in accordance with the requirements of the Phoenix Electrical Code.

++ END OF SECTION ++

SECTION 16136

OUTLET BOXES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish and install outlet boxes for mounting wiring devices and lighting fixtures.

1.2 QUALITY ASSURANCE

A. Reference Standards: Comply with applicable provisions and recommendations of the following, except where otherwise shown or specified:
   1. Phoenix Electrical Code, Article 370, Outlet, Switch and Junction Boxes and Fittings.
   2. UL Standard No. 514, Electrical Outlet Boxes and Fittings.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Manufacturers technical information for outlet boxes proposed for use.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Device Boxes:
   1. Material: Cast gray iron alloy, or cast malleable iron, with zinc electroplate finish in wet locations and zinc-coated sheet steel in dusty locations. Cast boxes shall be hub type and include external mounting lugs. In corrosive locations, boxes shall include a factory applied 40-mil PVC coating. In dusty locations, where conduit is installed concealed, boxes shall be steel galvanized and shall include suitable extension rings and covers, as required.
   2. Device Cover Plates:
      a. Stainless steel Type 302 alloy for indoor finished areas.
      b. Gasketed spring door type for wet and corrosive locations. Plates in corrosive locations shall include a factory applied 40-mil PVC coating.
      c. Integral with device for hazardous locations.
      d. Stainless steel screws and hardware.

3. Manufacturer: Provide device boxes of one of the following:
   a. Crouse-Hinds Company.
   b. Appleton Electric Company.
   c. Or equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Fasten boxes rigidly and neatly to supporting structures.

B. For units mounted on masonry or concrete walls, provide suitable 1/2-inch spacers to prevent mounting back of box directly against wall.

C. Leave no open conduit holes in boxes. Close unused openings with capped bushings.

D. Label each circuit in boxes and identify in accordance with Section 16122, 600 Volt Cable.

E. Install in conformance with Phoenix Electrical Code.

++ END OF SECTION ++

SECTION 16137

UNDERGROUND DUCT BANKS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope: Provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish and install underground duct banks.

B. Coordination: Duct bank routing on the Drawings is diagrammatic. Coordinate installation with piping and other underground systems and structures and locate clear of interferences.

C. Standard conduit chairs shall be used for all conduit raceway supports.

C. Definition: A duct bank is one or more buried electrical conduits.

1.2 QUALITY ASSURANCE

A. Reference Standards: Comply with applicable provisions and recommendations of the National Electrical Code.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Layouts showing the proposed routing of duct banks and the locations of manholes, handholes and areas of reinforcement.
   2. Profiles of duct banks showing crossings with piping and other underground systems.
   3. Typical cross sections.
   4. Installation procedures.

B. Record Drawings: Include the actual routing of underground duct runs on Record Drawings in accordance with Section 01782, Record Documents.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Duct: Schedule 40 PVC conduit and fittings in accordance with Section 16131 - PVC Coated Rigid Metal Conduit, Rigid Nonmetallic Conduit, and Electrical Metallic Tubing.

B. Exposed: PVC Coated Galvanized Rigid Metal Conduit: PVC coated rigid metal conduit and fittings in accordance with Section 16131, Rigid Conduit, if required.

C. Backfill: Select backfill in accordance with Section 02315, Structural Excavation and Backfill.

D. Reinforcement: In accordance with Section 03200, Concrete Reinforcement.

E. Concrete: In accordance with Section 03300, Cast-In-Place Concrete.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Duct banks shall be installed as follows:
   1. For small direct burial duct banks (3 conduits or less) use of PVC coated rigid metal conduit. Concrete and reinforcement are not required. Warning tape is required.
   2. For larger duct banks, use PVC conduit, to be encasement, reinforcement and warning tape. All bends (vertical and horizontal) of 45º or more require PVC coated rigid metal conduit.
   3. Conduits containing circuits less than 50VAC or 50VDC shall be separated from other conduits by a minimum of 12 inches.

B. Excavation and backfilling required for duct bank installation.

C. All duct bank installations and penetrations through foundation walls shall be watertight and in accordance with Section 16131 - PVC Coated Rigid Metal Conduit, Rigid Nonmetallic Conduit, and Electrical Metallic Tubing.

D. Top of duct banks shall be a minimum of 24-inches below grade, unless otherwise approved by the ENGINEER.

E. Assemble duct banks using non-magnetic saddles, spacers and separators. Position the separators to provide 3-inch minimum concrete separation between the outer surfaces of the ducts. Side forms are only required to prevent excessive widening of the duct bank where over excavation has occurred.

F. Provide a 3-inch minimum concrete covering on sides, top and bottom of concrete envelopes around conduits. Concrete covering size shall be as shown on the Drawings. Add red oxide to concrete for easy identification during subsequent excavation. The red oxide is to be added in the concrete truck prior to the concrete being placed. Red oxide concrete shall include the entire duct bank, top and bottom unless under a slab.

G. Firmly fix ducts in place during placing of concrete. Carefully place and vibrate the concrete to ensure filling of all spaces between ducts.

H. Conduits entering floor mounted equipment, such as, switchgear compartments, motor control centers, transformers shall terminate with PVC coated rigid metal conduit factory 90º elbows, RNC risers and bell ends.

I. Reinforce all duct banks.
   1. Unless otherwise shown on the Drawings, reinforce with No. 4 longitudinal steel bars placed at each corner and along each face at a maximum parallel spacing of 18-inches on centers, and No. 3 tie-bars transversely placed at 18-inch maximum longitudinal intervals. Overlap of No. 3 tie-bars shall be a minimum of 4-inches.
   2. Maintain a maximum clearance of 1-inch from bars to the edge of the concrete encasement.
   3. Install dowel reinforcement rebar where duct bank meets other concrete structures.

J. Do not backfill with material containing large rock, paving materials, cinders, large or sharply angular substances, corrosive material or other materials which can damage or contribute to corrosion of ducts or cables or prevent adequate compaction of fill.

K. Slope duct runs for drainage toward manholes and away from buildings with a slope of approximately 3-inches per 100 feet.

L. Install a bare stranded copper duct bank ground cable (4/0 or as shown on drawings) in each duct bank envelope. Make ground electrically continuous throughout the entire duct bank system. Connect ground cable to building and station ground grid or to equipment ground buses. In addition, connect ground cable to steel conduit extensions of the underground duct system. Provide ground clamp and bonding of each steel conduit extension, where necessary to maintain continuity of the ground system. Terminate ground cable at last manhole or handhole for outlying structures.

M. After completion of the duct bank or utilizing existing ducts and prior to pulling cable, pull a mandrel, not less than 12-inches long and with a cross section approximately 1/4-inch less than the inside cross section of the duct, through each duct. Then pull a rag swab or sponge through to make certain that no particles of earth, sand or gravel have been left in the duct.

N. Pulling Rope/Tape
   1. Pulling rope or tape shall be constructed of polyester and factory lubricated. Nylon is not allowed.

O. Warning Ribbon:

1. Provide as stated in Specification Section 16131.

P. Plug and seal empty spare ducts entering buildings and structures. Install pulling tape in all empty spare ducts. Seal watertight all ducts in use entering buildings and structures in accordance with Section 16131 - PVC Coated Rigid Metal Conduit, Rigid Nonmetallic Conduit, and Electrical Metallic Tubing.

+ + END OF SECTION + +

SECTION 16138

MANHOLES AND HANDHOLES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish and install manholes and handholes.

B. Coordination: Coordinate manhole and handhole installation with piping, sheeting and other underground systems and structures and locate clear of interferences.

1.2 QUALITY ASSURANCE

A. Reference Standards: Comply with applicable provisions and recommendations of the following, except where otherwise shown or specified:
   1. National Electrical Code (NEC) current adoption.
   2. City of Phoenix – Amendments to the National Electrical Code.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Manufacturer's technical information for manholes, handholes and accessories proposed for use.
   2. Drawings showing interior and exterior dimensions and details of openings, jointing, inserts and reinforcing.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Material and Construction:
   1. Precast or cast-in-place type of reinforced concrete.
   2. Minimum interior dimensions as shown on the Drawings.
   3. Duct entrances sized and located to suit duct banks.
   4. Handholes and Manholes must have a bottom.

B. Accessories:
   1. Frames and Covers:
      a. Material: Cast iron conforming to ASTM A 48, Class 30A.

b. Covers: Watertight, sealed type marked "ELECTRICAL" in raised 2-inch letters. Identify covers as shown on the Drawings.
c. Frame shall be grouted on the manhole or handhole.
d. Product and Manufacturer: Provide frames and covers of one of the following:
   1) Neenah Foundry Company.
   2) Campbell Foundry Company.

2. Frames and Covers:
   a. Material: Covers and frames shall be cast aluminum alloy, Class H-20 highway rated.
   b. Covers: Watertight, sealed type marked "ELECTRICAL" in raised 2-inch letters. Identify covers as shown on the Drawings.
      1) Manhole covers to be 36 inch minimum.
   c. Frame shall be grouted on the manhole or handhole.
   d. Product and Manufacturer: Provide frames and covers of one of the following:
      1) Neenah Foundry Company.
      2) Campbell Foundry Company.
3. Pulling Irons:
   a. Material: Galvanized steel.
   b. Cast in the wall opposite to the centerline of each incoming duct bank and 12-inches below centerline of bottom line of ducts.
   c. Product and Manufacturer: Provide one of the following:
      1) Catalog No. 8119 by A.B. Chance Company.
      2) Catalog No. DU2T3 by McGraw Edison Company.
4. Cable Racks:
   a. Material: Galvanized steel.
   b. Cable racks shall adequately support cables with space allowed for future cables.
   c. Each rack shall be a vertical assembly of 24-inch cable racks extending from within 6-inches of the manhole roof slab to within 6-inches of the manhole floor.
   d. Product and Manufacturer: Provide one of the following:
      1) Catalog No. J-5125 by Joslyn Manufacturing Company.
      2) Catalog No. C203-1125 by A.B. Chance Company.
5. Cable Hooks:
   a. Material: Galvanized steel.
   b. Length: 7-1/2-inch minimum.
   c. Product and Manufacturer: Provide one of the following:
      1) Catalog No. J-5132A by Joslyn Manufacturing Company.
      2) Catalog No. C203-1132 by A.B. Chance Company.
6. Insulators:
   a. Material: Porcelain.
   b. Product and Manufacturer: Provide one of the following:
      1) Catalog No. J-5122 by Joslyn Manufacturing Company.
      2) Catalog No. C203-1120 by A.B. Chance Company.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install manholes and handholes where shown on the Drawings. Verify final locations in field. Responsibility belongs to CONTRACTOR for all excavation and backfilling required for installation.

B. Complete installation of manholes and handholes so that structures are watertight. Apply foam sealant to all openings and penetrations. Seal all conduit openings to provide a water/bug-tight seal.
   1. Product and Manufacturer: Provide one of the following:
      a. Type DUX - Duct Sealing Compound, as manufactured by O-Z/Gedney
      b. Type FST Foam Sealant, as manufactured by American Polywater Corp

C. Cable Supports in Manholes:
   1. Attach cable racks with 3-inch by 3/8-inch diameter "tamp-in" studs mounted in 1-inch holes drilled into walls of manholes in the absence of inserts. Apply PVC coating to all racks.
   2. Provide cable hooks to support each cable on each rack along the cable run within the manholes. Apply PVC coating to all hooks.
   3. Individually support each cable at each hook on porcelain insulators. Provide sufficient slack for each cable.
   4. Securely tie each cable in place at each insulator block to prevent excessive movement of insulators, cables, or fireproof tape. Tie cables with non-metallic 3/4-inch strapping tape as manufactured by 3M or tie down with nylon straps.

D. Grounding: Install a 3/4-inch by 10-foot copper-clad ground rod for each manhole. Bond all exposed metal manhole accessories and the concrete reinforcing rods with No. 4 AWG minimum bare copper wire and connect to the ground rod and to the duct bank ground cable.

E. Sump: Provide a 12-inch by 12-inch by 6-inch sump in manhole floor.

F. Provide grading rings for manholes when required to adjust cover to proper grade. Grading ring shall be minimum of 12-inches in height, constructed on the roof slab or cone section on which the manhole frame and cover shall be placed. The height of the grading ring shall be such as is necessary to bring the frame to the proper grade.

G. Metal Pullbox: Install NEMA 4X stainless steel wall mounted pullbox inside manholes/handholes where analog signal cables are mixed with power cables. Route conduits for analog cables directly into and out of metal pullbox so that no analog cables are exposed.

++ END OF SECTION ++

SECTION 16141

RECEPTACLES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish and install receptacles.

1.2 QUALITY ASSURANCE

A. Reference Standards: Comply with applicable provisions and recommendations of the following, except where otherwise shown or specified:
   1. Phoenix Electrical Code.
   2. UL Standard No. 1010, Electrical Receptacle - Plug Combinations for Use in Hazardous Locations.
   3. Phoenix Building Code.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Manufacturer's technical information for receptacles proposed for use.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Receptacles for Non-Hazardous Locations:
   1. Duplex grounding receptacle, two pole, three wire, 125 volt AC, 20 amperes.
      a. Product and Manufacturer: Provide one of the following:
         1) Catalog No. 5362, for dry indoor locations and Catalog No. 53CM62, for wet and corrosive locations, by Harvey Hubbell Incorporated.
         2) Catalog No. 5362, for dry indoor locations and Catalog No. 5362-CR, for wet and corrosive locations, by Arrow-Hart Incorporated.
         3) Or equal.
   2. Single grounding receptacle, corrosion resistant, two pole, three wire, 125 volt AC, 20 amperes.
      a. Product and Manufacturer: Provide one of the following:
         1) Catalog No. 53CM61, by Harvey Hubbell Incorporated.
         2) Catalog No. 5361-CR, by Arrow-Hart Incorporated.
         3) Or equal.

B. Receptacles for Hazardous Locations:
   1. Material: Factory sealed receptacle suitable for installation in Class I, Group D hazardous locations. Copper-free aluminum receptacle and cover with cast gray iron alloy or cast malleable iron mounting box with zinc electroplate finish. Receptacle rated at 20 amperes, 125 to 250 volt AC, two wire, three pole. Provide matching plug for each receptacle.
   2. Product and Manufacturer: Provide one of the following:
      a. Series CPS by Crouse-Hinds Company.
      b. Type CPS by Appleton Electric Company.
      c. Or equal.

C. Ground Fault Receptacles:
   1. Duplex receptacle, two pole, three wire, 125 volt AC, 20 amperes.
   2. If recepticles are installed outdoors, the receptacles must be rated Weather Resistant (WR) and must be marked as such on the receptacle itself with WR on the device.
   2. Product and Manufacturer: Provide one of the following:
      a. Catalog No. GF5362 or GFRS5326TR, by Harvey Hubbell Incorporated.
      b. Catalog No. TWRVGF20x, Cooper Wiring Devices

D. Surge Suppression Receptacles:
   1. Duplex grounding, surge suppression receptacle, two pole, three wire, 125 volt AC, 20 amperes, capable of absorbing a transient surge 6,000 volts minimum. Receptacle to include power on indicator light:
      a. Product and Manufacturer: Provide one of the following:
         1) Catalog No. 5350S by Harvey Hubbell Inc.
         2) Catalog No. 5380-GY by Leviton Manufacturing Company.

E. Power Receptacles: 480 volt interlocked receptacle with enclosed safety switch service outlet: Provide service outlets, quantity as shown on the Drawings for portable equipment.
   1. Material: Copper free aluminum enclosure with operating handle NEMA 4, with gasketed hinged door.
   2. Switch: Heavy duty, three pole, with visible blades, a quick make a break mechanism with reinforced, positive pressure type blade and fuse clips. Switch shall be mechanically interlocked with the receptacle. The switch cannot be closed until the plug is fully inserted and the plug cannot be withdrawn or inserted, unless the switch is open.
   3. Receptacle: Single ground receptacle, three wire, four pole, 600 volt, 60 amp. Provide two matching plugs.
      a. Type WSR, and Type APS plugs by Crouse-Hinds Company.

F. Power and Special Receptacles: Provide receptacles with number of poles and voltage and current rating as shown on the Drawings. Coordinate with equipment plugs. Provide matching plug for each receptacle.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install receptacles at locations as shown on the Drawings in outlet or device boxes in accordance with Section 16136, Outlet Boxes, in non-hazardous locations.

B. Install receptacles in PVC coated galvanized rigid steel conduit systems in hazardous locations.

C. Install receptacles with ground pole in the down position.

D. Mount receptacles 18-inches above finished floor, or in accordance with Phoenix Building Code, in non-hazardous locations and 4 feet-6 inches above finished floor in hazardous locations, unless otherwise noted.

E. Identify each conductor with the circuit number and the lighting panel number. Identification shall conform to the requirements of Section 16122, 600 Volt Cable.

F. Identify each receptacle with a permanent self adhesive label. Approximate size 3/8" x 1¼". The label shall include the panel name and circuit number.
   a. Product and Manufacturer: Provide one of the following:
      1) Catalog No. PTL-45422 by Brady.
      2) Or Equal

G. Install in conformance with Phoenix Electrical Code.

++ END OF SECTION ++

SECTION 16142

SNAP SWITCHES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish and install snap switches for lighting and other systems.

1.2 QUALITY ASSURANCE

A. Reference Standards: Comply with applicable provisions and recommendations of the following, except where otherwise shown or specified.
   1. National Electrical Code (NEC) current adoption.
   2. City of Phoenix – Amendments to the National Electrical Code.
   3. UL Standard No. 20, General Use Snap Switches.
   4. UL Standard No. 894, Switches for Use in Hazardous Locations.
   5. Phoenix Building Code.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Manufacturer's technical information for switches proposed for use.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Switches for Non-Hazardous Locations:
   1. Single pole AC toggle switch, quiet type, 120/277 volt AC, 20 amperes, Ivory, specification grade.
      a. Product and Manufacturer: Provide one of the following:
         1) Catalog No. 1221-I, by Harvey Hubbel Incorporated.
         2) Catalog No. 1991-I, by Arrow-Hart Incorporated.
   2. Single pole, 3-way AC toggle switch, quiet type, 120/277 volt AC, 20 amperes, Ivory, specification grade.
      a. Product and Manufacturer: Provide one of the following:
         1) Catalog No. 1223-I, by Harvey Hubbell Incorporated.
         2) Catalog No. 1993-I, by Arrow-Hart Incorporated.

3. Two pole AC toggle switch, quiet type, 120/277 volt AC, 20 amperes, Ivory, specification grade.
    a. Product and Manufacturer: Provide one of the following:
        1) Catalog No. 1222-I, by Harvey Hubbel Incorporated.
        2) Catalog No. 1992-I, by Arrow-Hart Incorporated.

B. Switches for Hazardous Locations:
1. Material: Factory sealed tumbler switch suitable for installation in Class I, Group D hazardous locations. Cast gray iron alloy or cast malleable iron body and cover with zinc electroplate finish. Switch rated at 20 amperes, 120/277 volt AC.
2. Product and Manufacturer: Provide one of the following:
    a. Series EDS by Crouse-Hinds Company.
    b. Type EDS by Appleton Electric Company.

C. Switch Covers:
1. Indoor covers shall be Type 304, stainless steel.
2. Outdoor or wet location covers shall be weatherproof and corrosion resistant.

D. Key Operated On-Off Switches:
1. Key operated switches shall be complete with legend plate and NEMA 4 enclosure and two keys for each switch.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install switches at locations as shown on the Drawings in outlet or device boxes in accordance with Section 16136, Outlet Boxes, in non-hazardous locations.

B. Install switches in PVC coated galvanized rigid steel conduit systems in hazardous locations.

C. Mount wall switches 4 feet-6 inches above finished floor or in accordance with Phoenix Construction Code, unless otherwise noted.

D. Identify each conductor with the circuit number and the lighting panel number. Identification shall conform to the requirements of Section 16122, 600 Volt Cable.

E. Install switches in conformance with Phoenix Electrical Code.

++ END OF SECTION ++

SECTION 16143

DISCONNECT SWITCHES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish and install disconnect switches.

1.2 QUALITY ASSURANCE

A. Reference Standards: Comply with applicable provisions and recommendations of the following, except where otherwise shown or specified:
   1. National Electrical Code (NEC) current adoption.
   2. City of Phoenix – Amendments to the National Electrical Code.
   3. UL Standard No. 98, Enclosed Switches.
   4. NEMA KS-1, Enclosed Switches.
   5. NEMA 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Manufacturer's technical information for disconnect switches proposed for use.
   2. Snap Switches (for disconnect switches on 120 volt, single phase circuits) coordinate with Section 16142.
   3. Listing of the switches to be furnished with an identification of their location, rating and NEMA enclosure type.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Service Disconnect Switches:
   1. Type: Fused, heavy-duty, single throw, quick-make, quick-break mechanism, visible blades in OFF position and safety handle.
   2. Rating: Voltage, current and short circuit ratings and number of poles as shown on the Drawings. Switch shall bear a UL label certifying suitability for use as service equipment.
   3. Provide auxiliary dry contacts to indicate switch position.

B. Submersible Pumps' Disconnect Switches (and cable termination):

1. Type: Fused, heavy-duty, single throw, quick-make, quick-break mechanism, visible blades in OFF position and safety handle. Enclosures shall be NEMA 4X, type 316 Stainless Steel, vandal resistance and equipped with pad lock mechanism.
2. Rating: Voltage, current and short circuit ratings and number of poles as shown on the Drawings. Switch shall bear a UL label certifying suitability for use as service equipment.
3. Lugs shall be rated as indicated on the Drawings and for 75 degrees Centigrade termination.
4. Provide auxiliary dry contacts to indicate switch position.

C. Single Throw, Circuit Disconnect Switches:
1. Type: Fused or unfused, horsepower rated, heavy-duty, single throw, quick-make, quick-break mechanism, visible blades in the OFF position and safety handle.
2. For applications where the line side of the power circuits are daisy-chained between the disconnect switches, the disconnect switches shall be equipped with double lugs and UL rated as such.
3. Rating: Voltage and current ratings and number of poles as required for motor or equipment circuits being disconnected. Switches shall bear a UL label.
4. Provide auxiliary dry contacts to indicate switch position.

D. Double Throw Safety Switches:
1. Type: Unfused, double throw with center OFF position, quick-make, quick-break mechanism, visible blades in the OFF position and safety handle.
2. Rating: Voltage and current ratings and number of poles as required for the circuits being disconnected.
3. Provide auxiliary dry contacts to indicate switch position.

E. Enclosures:
1. NEMA 12 for dry, indoor non-corrosive areas.
2. In all other locations except wet or corrosive, NEMA 4X 304 stainless steel. For wet or corrosive locations, NEMA 4X 316 stainless steel.
3. NEMA 7 for explosion proof areas.

F. Identification:
1. Identify all enclosures in accordance with Section 16050, General Provisions.
2. Manufacturer's nameplates identifying equipment, include identification of the equipment served and source of power, for which switches serve as the disconnecting means. Manufacturer's nameplates shall be permanently fastened to enclosures.
3. Comply with the requirements of Section 01630, Computerized Maintenance Management System Tags.

G. Product and Manufacturer: Provide one of the following:
1. ABB.

2. Square D.
3. Eaton

PART 3 - EXECUTION

3.1 INSTALLATION

A. Mount equipment so that sufficient access and working space is provided for ready and safe operation and maintenance.

B. Securely fasten equipment to walls or other structural supports on which they are mounted. Provide independent stainless steel supports where no wall or other structural surface exists.

C. Furnish one set of spare fuses for each fused disconnect switch to be installed.

D. Install in conformance with Phoenix Electrical Code.

++ END OF SECTION ++

SECTION 16144

CONTROL STATIONS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish and install pushbuttons, selector switches and other control stations.

1.2 QUALITY ASSURANCE

A. Reference Standards: Comply with applicable provisions and recommendations of the following, except where otherwise shown or specified.
   1. NEMA Standard ICS2-216, Pushbuttons, Selector Switches, Indicating Lights and Pushbutton Stations.
   2. National Electrical Code (NEC) current adoption.
   3. City of Phoenix – Amendments to the National Electrical Code.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Manufacturer's technical information for control stations proposed for use.

B. Control stations shall be furnished in accordance with the requirements as shown on the Drawings, and as specified in Division 17000, Sections 17051, 17052, 17053, and 17226.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Control Stations:
   1. Type: Industrial, heavy duty, oil tight construction with clearly marked Type 316 stainless steel or non-metallic material nameplates identifying equipment controlled.
   2. Enclosures: NEMA 12 for dry indoor locations, NEMA 4X for outdoor and damp, wet or corrosive indoor locations. NEMA 4X stations shall be stainless steel and shall have locking rings, nameplates and all external hardware and components shall be Type 316 stainless steel or non-metallic material.

3. Emergency Stop: Maintained contact type, NEMA A600 contact rating, color red with clearly marked Type 316 stainless steel or non-metallic material nameplate identifying equipment operation, provide as shown on drawings.
4. Pushbuttons: Momentary contact types, NEMA A600 contact rating, with clearly marked Type 316 stainless steel or non-metallic material nameplate identifying equipment operation, provide as shown on drawings.
   a. Stop: Boot color to be red.
   b. Start: Boot color to be black.
5. Selector Switches: Rotary type with round or oval handles and positioning device to securely hold switch in selected position for maintained type and for spring return from left, right, or both to a maintained position with clearly marked Type 316 stainless steel or non-metallic material nameplate identifying equipment operation, provide as shown on drawings.
6. Indicating Lights: 120 VAC, Push-To-Test. Lens color red for running, green for stopped or ready and amber for failure with clearly marked Type 316 stainless steel or non-metallic material nameplate identifying equipment operation, provide as shown on drawings.
7. Product and Manufacturer: Provide control stations of one of the following:
   a. To match existing

PART 3 - EXECUTION

3.1 INSTALLATION

A. Mount equipment, as shown on the Drawings, so that sufficient access and working space is provided for ready and safe operation and maintenance.

B. Securely fasten equipment to walls or other surfaces on which they are mounted. Provide independent stainless steel or FRP supports where no wall or other surface exists.

C. Install in conformance with Phoenix Electrical Code.

++ END OF SECTION ++

SECTION 16215

POWER SYSTEM / ARC FLASH ANALYSIS

PART 1 - GENERAL

1.1 DESCRIPTION

A. General:
1. Conduct a Power System Short Circuit Study, Protective Device Coordination Study, and Arc Flash Hazard Analysis for the Electrical Distribution System (EDS) as specified in the CONTRACT DOCUMENTS.
2. The CONTRACTOR shall contract with the City's Electrical, Instrumentation and Control Inspection Firm (EI&C Inspection Firm) to perform the POWER SYSTEM / ARC FLASH HAZARD ANALYSIS. The EI&C Inspection Firm will perform the POWER SYSTEM / ARC FLASH HAZARD ANALYSIS and shall here in be referred to as ANALYSIS FIRM.
3. The software used to conduct the study and analysis shall be the latest version of SKM Power*Tools, by SKM Systems Analysis, Inc.

1.2 SCOPE

A. CONTRACTOR Scope:
1. The CONTRACTOR shall be responsible for providing the following data to the ANALYSIS FIRM:
   a. Project Schedule.
   b. Electrical Utility contact information.
   c. Division 16000 Engineer approved submittals, including the ENGINEERS review comments.
   d. Additional equipment information as requested by the ANALYSIS FIRM per Section 1.2.A3.
   e. Marked up single line diagram(s) with installed conductor lengths, sizes and count.
   f. Changes in design as a result of RFI's, Addendums, Engineer Clarifications, Sketches or revisions, which may affect the Power System / Arc Flash Analysis.
2. CONTRACTOR shall provide ANALYSIS FIRM a minimum of a 2-week notice of the following construction milestones:

a. Electrical Equipment Delivery.
b. Electrical Equipment Energization.
c. Electrical Equipment Testing.
d. Substantial Completion.

3. Based upon outcome of analysis additional equipment information may be required by the CONTRACTOR for upstream or downstream equipment in the electrical distribution system.
4. CONTRACTOR shall be responsible for implementation of the protective device settings. Implementation of recommended settings outside of the project scope of work resulting from system coordination changes is the responsibility of the OWNER.
5. CONTRACTOR shall provide ANALYSIS FIRM with safe access to all equipment on site throughout construction for the purpose of verifying the EDS protective device information.
6. CONTRACTOR shall install labeling as required by specification 16050 section 3.1 for voltage labeling and other labels as required.

B. ANALYSIS FIRM Scope

1. Conduct a Power System/Arc Flash Hazard Analysis for new and modified areas of the EDS as specified in the CONTRACT DOCUMENTS. The analysis shall be performed in accordance with IEEE and shall utilize the ANSI method of short circuit analysis. An SKM model of the EDS shall be developed or modified using ENGINEER'S approved Equipment Submittals, site collected data, and Utility short circuit data. Deliverables shall include a short circuit analysis results, a protective device coordination analysis results, and arc flash / shock hazard analysis results and work tasks required by the CONTRACTOR. The ANALYSIS FIRM shall coordinate new protective devices with existing protective devices in the EDS as required.
2. Where additional electrical equipment is being added or modified and upon request from the ANALYSIS FIRM, the ENGINEER will transmit the existing Arc Flash Documentation from the City (or from the Contractor) to the ANALYSIS FIRM for use in completing the required updates.
3. ANALYSIS FIRM shall acquire the Electrical Utility Company's published available Short Circuit current tables for use in the studies. For larger service sizes greater than 480VAC, the ANALYSIS FIRM is to coordinate with the Utility Company for calculated available short circuit current.
4. ANALYSIS firm shall verify that protective devices are correct per SKM model and analysis results.
5. ANALYSIS FIRM shall install Arc Flash Hazard Warning labels per this specification.
6. ANALYSIS FIRM shall install the updated laminated Single Line Diagram's, Panel Schedules, and Load Summaries. Updates will be made by the ANALYSIS FIRM based on as-build documentation provided by the CONTRACTOR.

7. ANALYSIS FIRM shall deliver the final SKM Model and all associated data and library files used in the model to the OWNER. The ANALYSIS FIRM shall relinquish all rights of the SKM model and all associated data and library files to the OWNER.

1.3 REFERENCES

A. Reference Standards: Comply with applicable provisions and recommendations of the following, except where otherwise shown or specified.
   1. IEEE 141-1993, Recommended Practice for Electric Power Distribution for Industrial Plants (IEEE Red Book).
   2. IEEE 242-2001, Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (IEEE Buff Book).
   3. IEEE 1584-2002, Guide for Performing Arc Flash Hazard Calculations
   4. NFPA 70E, Standard for Electrical Safety in the Workplace.
   5. IEEE 551, Recommended Practice for Calculating Short-Circuit Currents in Industrial and commercial Power Systems (IEEE Violet Book).
   6. NFPA 70, National Electrical Code (NEC).

1.4 SUBMITTALS

A. Preliminary Technical Memorandum:
   1. ANALYSIS FIRM shall provide a preliminary submittal review and a technical memorandum providing comments for equipment submitted on. This will be submitted for approval by the ENGINEER and OWNER. Submittal shall include:
      a. Technical Memorandum
         1) Review for adequate installation based on available fault current.
         2) Recommendations for alternate equipment based on system coordination.
         3) Recommendations for alternate design considerations based on energy levels.
   2. Preliminary Technical Memorandum shall be submitted (prior to the Contractor submitting shop drawings of the equipment) and reviewed by the ENGINEER to ensure EDS electrical equipment order being released for manufacturing meets the requirements of the project.

B. Final Report:
   1. ANALYSIS FIRM shall submit a final sealed report to the CONTRACTOR upon project substantial completion. Final report shall be in PDF format and include all documents as noted in section 1.4.B.2 below.
   2. ANALYSIS FIRM to provide the following documents in the final report:
      a. Final Report
      b. SKM Single Line Diagrams – Power Study Management Scenario
      c. SKM Time Current Curves
      d. Arc Flash Labels

C. Submittals shall be delivered in pdf format, unless otherwise specified. CONTRACTOR shall provide four (4) cd(s) of the final deliverable report to the ENGINEER.

PART 2 - PRODUCTS

2.1 POWER SYSTEM / ARC FLASH ANALYSIS FINAL REPORT

A. Professional Certified Report:
   1. ANALYSIS FIRM shall provide a certified report that shall include but is not limited to:
      a. An executive summary.
      b. Methods, assumptions, and procedures used in the analysis.
      c. Results of short-circuit analysis listing equipment that is applied above its short-circuit current rating, and recommendations if appropriate.
      d. Results and recommendations of the protective device coordination and time-current analysis, including time-current curves (TCC's).
      e. Documentation of all study input data, including utility available fault currents; cable sizes, types and lengths; motor data; breaker types and settings; fuse sizes and types, etc.
      f. Findings and recommendations requiring actions not within the ANALYSIS FIRM scope of work.
      g. Electrical Distribution System Overview as illustrated on the CONTRACT DOCUMENTS.
      h. Appendices with the SKM documents of the equipment data used in the analysis and the analysis results.
   2. Report shall be reviewed and sealed by a Professional Engineer registered in the state of Arizona.

B. SKM Single-Line Diagram(s):
   1. SKM Single-Line Diagram(s) legible on 11" x 17" sheet size, landscape view. Include the following information:
      a. Location and function of each protective device in the system, such as relays, direct-acting trips, fuses, etc.
      b. Type designation, current rating, range or adjustment, manufacturer's style or type for all protective devices.
      c. Power, voltage ratings, impedance, primary and secondary connections of all transformers.
      d. Type, manufacturer, and ratio of all current transformers energizing each relay.
      e. Manufacturer's nameplate data of all motors and generators.
      f. Sources of short circuit currents such as utility ties, generators, synchronous motors, and induction motors.
      g. All significant circuit elements such as transformers, cables, breakers, fuses, reactors, etc.
      h. Normal switching conditions where possible.
      i. The final settings of adjustable breakers, relays and direct-acting trips.

C. Short Circuit Study:
   1. The short circuit analysis shall be performed to determine the adequacy of circuit breakers, surge arresters, busways, switches, and fuses by tabulating and comparing the short circuit ratings of these devices with the available fault currents. Short circuit momentary duties and interrupting duties shall be calculated on the basis of worst case scenario / maximum available fault current at the switchgear busses and motor control centers.
   2. Normal system operating method, alternate operation, and operations which could result in maximum fault conditions shall be thoroughly addressed in the analysis. The analysis shall assume all motors operating at rated voltage. Redundant/standby motors shall be excluded where known system limitations prevent simultaneous operation. Electrical equipment bus impedance shall be assumed zero (SKM default setting).

D. Protective Device Coordination Study:
   1. The protective device coordination analysis shall be performed to determine the required settings/sizes of the protective devices to maximize selectivity. The phase over-current and ground-fault protection settings shall be included as well as settings for all other adjustable protective devices, excluding vendor supplied packaged equipment. Areas lacking complete coordination shall be identified and justification provided for allowing condition to remain, or the ENGINEER shall provide solution to resolve situation.

2. SKM Time-Current Curve(s) legible on 11" x 17" sheet size, landscape view on 10- cycle, green log-log graph paper. Include the following information for each time-current curve:
   a. Protective device, relay, or fuse showing graphically that the settings provide protection and selectivity within industry standards. Each curve shall be identified, and the tap and time dial settings shall be specified.
   b. Each device shall be positioned to provide maximum selectivity to minimize system disturbances during fault clearing. Where selectivity cannot be achieved, the ENGINEER shall be notified as to the cause.
   c. Points for cable and equipment damage.
   d. Circuit interrupting device operating and interrupting times based on the amperage.
   e. A SKM Single line sketch of bus and breaker arrangement for each time-current curve.
3. Provide breaker setting table with sign off form for CONTRACTOR use during implementation of breaker settings.

E. Arc Flash/Shock Hazard Analysis:
1. The arc flash / shock hazard analysis shall be conducted in accordance with the methods outlined in IEEE Standard 1584 and stated hereinafter. Work shall be in accordance with NFPA 70E which includes the fabrication of labels with the Arc Flash / Shock Hazard analysis results, the calculated Incident Energy (cal/cm^2), Equipment Name, Owner and Owner contact information, and the date the analysis was performed.
2. The analysis shall include the following IEEE 1584 analysis process steps:
   a. Collect current and accurate system and installation data.
   b. Determine modes of operation.
   c. Determine bolted fault current.
   d. Determine arc fault current.
   e. Determine protective device characteristic and arc fault duration.
   f. Document system voltages
   g. Select working distances.
   h. Calculate Incident Energy (cal/cm^2).
   i. Calculate the Arc Flash Boundary.
3. Within the final report, provide a copy of each installed Equipment Specific Arc Flash label on 8½" x 11" sheet size, portrait view in actual size and color as printed and installed on the actual field equipment.

2.2 LABELS

A. Arc Flash Hazard Warning Labels:
1. PPE Category Label:

a. A standard Arc Flash Hazard Warning label (Category Label) shall be installed on all equipment that meets the NFPA 70E Category 1 or 2 parameters, including a maximum of 25 kA available fault current and arc-duration parameters (clearing time). All other components must have an equipment specific label generated from SKM using calculated values as described in 2.2.A.2.

b. Provide a 2" x 4" label format with coloring to match the labels shown on Figure 2.2.B.1 below.

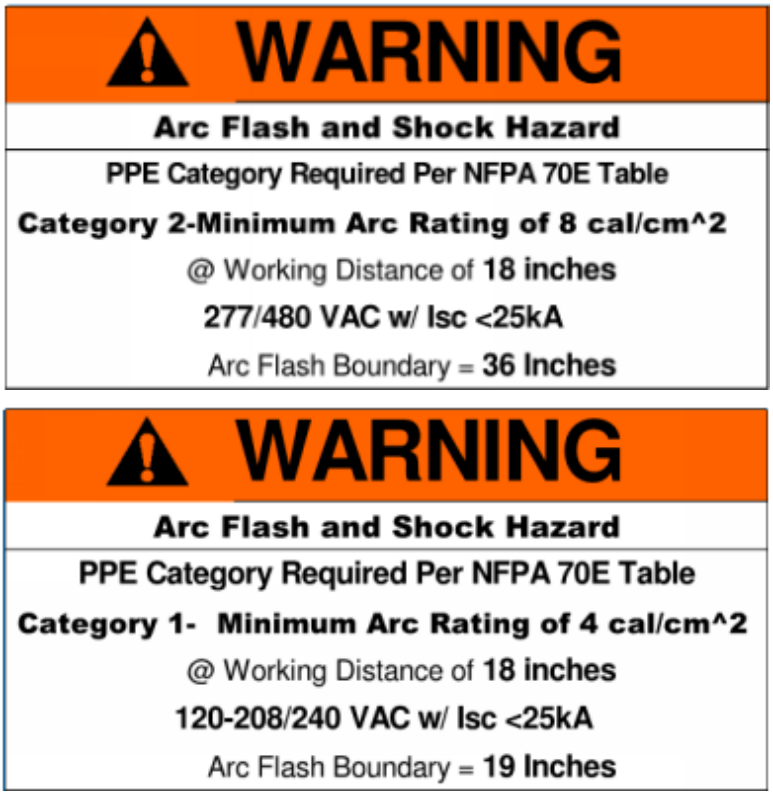

Figure 2.2.B.1

2. Calculated Equipment Specific Labels:

a. Arc Flash and Shock Hazard Warning labels shall be installed on all equipment with an SKM calculated Incident Energy level.

b. Label shall have an orange header with the wording, "WARNING, Arc Flash and Shock Hazard," and shall include the following information taken directly from the arc flash hazard analysis:

1) Equipment designation.
2) Nominal system voltage.
3) Protection boundaries:
   a) Arc Flash Boundary.
   b) Limited approach boundary.

c) Restricted approach boundary.

c. Calculated available incident energy in cal/cm^2 and the corresponding working distance.
d. Owner: City of Phoenix
e. Contact Info Phone Number. **(602) 495-7692**
f. Study Date.
g. Labels shall be machine printed, with no field-applied markings.
h. Provide standard 4" x 5" rectangular labels.
i. Provide a label with coloring and formatted to match Figure 2.2.B.2 below.

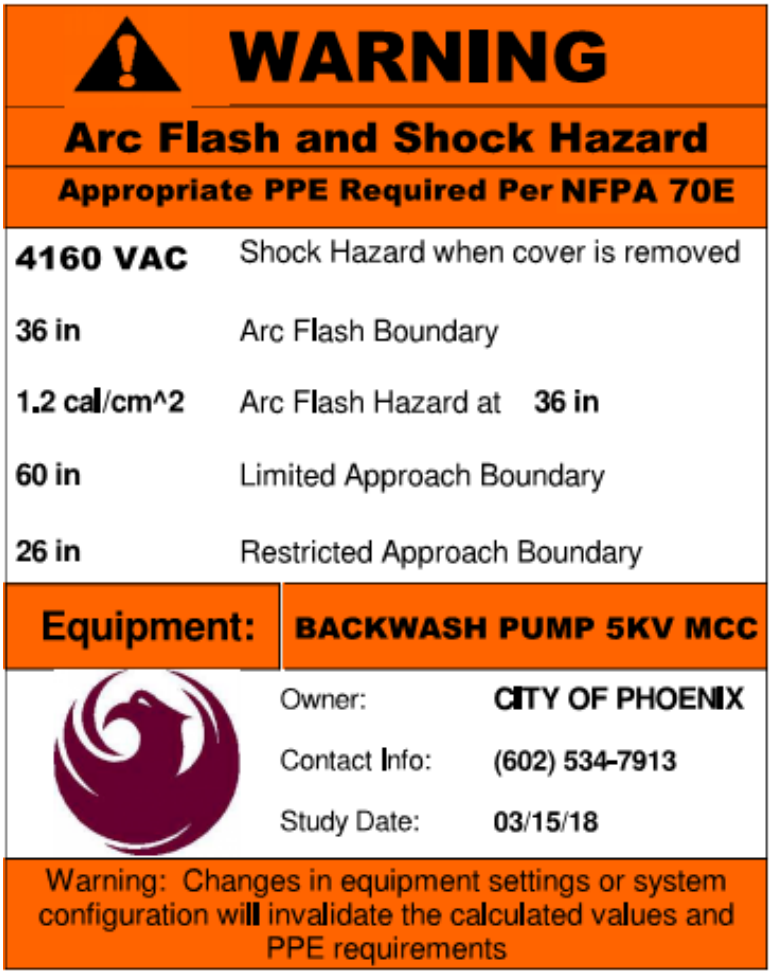

Figure 2.2.B.2

3. Label Material:
   a. Label shall be an indoor/outdoor high performance, pressure sensitive safety sign.
   b. Materials shall be UV rated surface printed polyester with polyester over-laminate. Labels shall be abrasion, chemical and heat resistant (-40°C to 110°C), with an average outdoor durability of five to eight years.
   c. Comply with ANSI Z535.4 for safety signs and labels.
   d. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.
   e. Product Manufacture: Provide the following:
      1) Printer and Label Materials
         a) BRADY Powermark Printer, BRADY Label Part# 13651
         b) Or Approved Equal.

PART 3 - EXECUTION

3.1 GENERAL

A. ANALYSIS FIRM shall inspect all installed equipment for conformance with the fully executed POWER SYSTEM / ARC FLASH ANALYSIS. Any deviations found shall immediately be brought to the OWNER and ENGINEERS attention.

3.2 BREAKER SETTINGS

A. The CONTRACTOR shall coordinate with the ENGINEER and ANALYSIS FIRM to implement the breaker settings defined in the approved preliminary report submittal.
   1. The CONTRACTOR shall complete form 16215 – A – Power System / Arc Flash Analysis Sign-off Form for each breaker.

B. The ANALYSIS FIRM shall inspect all breaker settings implemented in the field by the CONTRACTOR. If the recommended breaker setting(s) are adjusted, the ANALYSIS FIRM will update the final report with the actual settings. CONTRACTOR or ENGINEER is to provide written justification for any deviations.

3.3 BREAKER TESTING

A. The CONTRACTOR shall coordinate the final settings of the breakers during the start-up and functional testing of the process systems EDS. If the breaker settings require adjustment, the CONTRACTOR will coordinate with the ENGINEER and ANALYSIS FIRM to update the Power System Arc Flash Analysis Report with the final settings.

3.4 LABELING

A. All Service Entrance Sections (SES), switchboards, switchgear, Motor Control Centers (MCC), transformers, distribution boards, panel boards, disconnects and control panels shall have both an Arc Flash Hazard Warning label and a voltage label as identified in specification section 16050. The ANALYSIS FIRM shall determine the proper Arc Flash Hazard Warning label.
   1. Install all labels level and in an upright position. Do not cut or alter in any way. Install labels in a professional manner. Clean surface as needed to allow for good adhesion.
   2. Labels shall not be installed atop any manufacturer name plate data or equipment tag labels.
   3. Labels shall not be installed atop any existing voltage warning or Arc Flash Hazard Warning labels that may already exist on the equipment. Existing voltage and Arc Flash Hazard Warning labels shall be removed and the surface thoroughly cleaned before application of any new labels.
   4. Where equipment does not have sufficient space for an Arc Flash Label the CONTRACTOR shall furnish a fabricated mounting plate constructed of stainless steel sheet metal per. Mounting plate shall be affixed to the equipment using stainless steel screws. Installation shall maintain the equipment NEMA rating of the equipment. Mounting plate shall not interfere with equipment operation and shall be readily visible.
   5. In the case of more than one source of power to a piece of equipment, the highest voltage label shall be applied, and an additional label shall be applied indicating more than one source of power located inside the equipment.
   6. For outdoor switchgear, place a single Arc Flash Hazard Warning label on the outside of the access door nearest to the main breaker, and one inside on the respective breaker enclosure. All other Arc Flash Hazard Warning labels shall be placed inside the access doors on the respective breaker enclosure or cover. If there are back access panels to the equipment, the arc flash labels placed at the front of the gear shall be duplicated and placed on the back access panels at the same relative location.
   7. For disconnect switches, panel boards, distribution boards, load centers, and control panels, the labels should be applied in plain view on the front cover.

3.5 TRAINING

A. Provided for operation and maintenance personnel training services. The STUDY

FIRM representative shall make a minimum of one (1) visits to the site to perform the services as described under Section 01821, Instruction of Operations and Maintenance Personnel. The representative shall coordinate each visit with the ENGINEER prior to arrival on the site.

+ + END OF SECTION + +

SECTION 16425

VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment, and incidentals required to furnish and install variable frequency drives (VFD), complete and operational with controls and accessories as shown on the Drawings and as specified. Type 316 stainless steel anchor bolts shall be included and shall be furnished in this Section.
   2. **The pump monitoring system is provided by the pump manufacturer and shall be installed by the VFD supplier/vendor within the VFD enclosure**.

B. Coordination: Coordinate speed control, starting and acceleration torque requirements with the driven equipment. Submit an acceptance letter from the driven equipment and motor manufacturers stating that each VFD will fully meet all starting and operating requirements of the respective driven equipment/motor combination. Responsibility belongs to CONTRACTOR for coordinating all VFD units with the driven equipment to obtain successful operation throughout the driven equipment speed range.

1.2 QUALITY ASSURANCE

A. Manufacturer's Qualifications:
   1. Manufacturer shall have a minimum of five years experience of producing substantially similar equipment, and shall be able to show evidence of at least five installations in satisfactory operation for at least five years. Prototypes or newly introduced drive unit models will not be acceptable.

B. The manufacturer shall demonstrate, in writing, the Quality Assurance Program in use to certify key components. In-house manufacture of key components is desirable, and will be considered in evaluating acceptance.

C. Reference Standards: Comply with applicable provisions and recommendations of the following, except as otherwise shown or specified.
   1. National Electrical Code (NEC) current adoption.
   2. City of Phoenix – Amendments to the National Electrical Code.
   3. Standards of National Electrical Manufacturers Association.
   4. Institute of Electrical and Electronic Engineers.
   5. American Gear Manufacturers Association.
   6. National Fire Protection Association 79, Electrical Standard for Industrial Machinery.

D. For the equipment specified herein, the manufacturer shall be ISO 9000, 9001 or 9002 certified.

E. Unit Responsibility: Assign Unit Responsibility as specified in Section 01600, General Equipment Provisions, to the manufacturer or supplier for the equipment specified in this Section. A Certificate of Unit Responsibility shall be provided.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Manufacturer's literature, illustrations, specifications and engineering data which indicate performance, dimensions, materials, size and weight.
   2. Complete list of components and catalogue identification.
   3. List of in-house manufactured key components.
   4. Quality Assurance Program description.
   5. Complete description of schematic and wiring diagrams and functional operation.
   6. Recommended spare parts list.
   7. Wiring diagram including the **pump monitoring system** that is provided by the pump manufacturer and installed by the VFD supplier/vendor within the VFD enclosure.

B. Operation and Maintenance Manuals:
   1. Submit complete installation, operation and maintenance manuals including test reports, maintenance data and schedules, description of operation and spare parts information.
   2. Furnish Operation and Maintenance Manuals in conformance with the requirements of Section 01781, Operation and Maintenance Data.
   3. Furnish list of final parameters and function selections programmed into each drive control module.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Deliver materials to the site to ensure uninterrupted progress of the Work. Deliver anchor bolts and anchorage devices which are to be embedded in cast-in-place concrete in ample time to prevent delay of the Work.

B. All boxes, crates and packages shall be inspected by CONTRACTOR upon delivery to the site. Notify ENGINEER of any loss or damage exists to equipment or components. Replace loss and repair damage to new condition in accordance with manufacturer's instructions.

C. Store materials to permit easy access for inspection and identification. Keep all materials off the ground, using pallets, platforms or other supports. Protect steel members and packaged materials from corrosion and deterioration.

D. Store all electrical and electronic equipment, control panels, and like equipment and materials in heated buildings which have a concrete or wooden floor, a roof, and fully closed walls on all sides. Protect electrical and electronic equipment from contamination by dust, dirt and moisture. Maintain humidity at levels recommended by manufacturer for electric and electronic equipment.

E. Energize space heaters during storage.

1.5 SHOP TESTS

A. Each variable frequency drive (VFD) shall be tested at the manufacturer's facility.

B. In addition to the manufacturer's standard tests, each VFD, including all instruments, controls, solid state components, systems, and internal and external equipment which are a part of the VFDs shall be assembled, tested and thoroughly checked for proper operation of all functions and features. Simulated signals and loads shall be employed that shall simulate actual signals and loads, if they are a part of the final installation and are not included in this Section.

C. If the test results indicate that any VFD unit does not conform to specified and/or guaranteed performance, the unit shall be modified and retested, at no additional cost to OWNER, until full compliance with specified and guaranteed performance can be demonstrated. OWNER and/or ENGINEER shall be permitted to witness the retest.

D. No equipment shall be shipped until the ENGINEER has approved all test reports.

PART 2 - PRODUCTS

2.1 GENERAL

A. Furnish and install variable frequency drive units, AC PWM inverter type, 460 volts, sine coded with carrier frequency adjustment, 3 phase, 60 hertz input with output suitable for and coordinated with the driven equipment furnished under the appropriate Sections in Division 11, Equipment. Drives rated 75 horsepower and above shall utilize active front end inputs and phase shifting transformer to reduce harmonic output.

B. The drives shall have the following characteristics:
   1. Output voltage (Maximum): 460 volts.
   2. Frequency accuracy: ±0.5 percent (at 25°C ±10°C).
   3. Frequency range: 3 to 67 hertz, selectable by switch to 120 hertz (Except where otherwise indicated).
   4. Volts per hertz ratio (V/HZ) adjustable for 3 to 60 hertz.
   5. Overload capacity shall be one minute at 125 percent of continuous constant torque rated nameplate current. The inverter shall be designed to not be internally shutdown within the 125 percent overload operating range.

6. Constant torque rated for motor nameplate horsepower without revision of inverter unit manufacturer's nameplate published constant torque rating.

C. VFD's shall meet all requirements as outlined in the latest edition of IEEE 519 for total harmonic voltage and current distortion and as indicated in this Section. Individual or simultaneous operation of the VFDs shall not add more than three percent total harmonic voltage distortion while operating. Maximum allowable total harmonic current distortion limits for each VFD shall not exceed five percent as calculated and measured at the point of common coupling. The point of common coupling for all harmonic calculations and field measurements for both voltage and current distortion shall be defined as the nearest upstream MCC. A preliminary harmonic analysis must be submitted by the VFD manufacturer with Shop Drawings which includes all voltage and current harmonics up to the 99th harmonic; for this purpose cable lengths can be estimated on a conservative basis by CONTRACTOR. Compliance shall be verified with onsite field measurements of both the voltage and current harmonic distortion at the defined point of common coupling with and without the VFD's operating.

D. Product and Manufacturer: Pending compliance with the Drawing, Specifications, and dimensions (foot prints and heights), and matching the existing conduit entries, provide one of the following. **Please note that custom work may be required to fit the proposed VFDs into the indicated spaces and conduit entry requirements**:
1. ABB.
2. Square D.
3. Eaton

2.2 DETAILS OF CONSTRUCTION

A. All individually mounted VFD's shall be housed in NEMA 1 wall or floor mounted cabinets configured as shown on the Drawings. All other VFD's shall be housed within motor control centers (VFD's in motor control centers shall be built by the same manufacturer as the motor control centers) and configured as shown on the Drawings. VFD units shall be individually fed from circuit breakers located in the motor control centers or switchboards as shown on the Drawings. Conduit and cable entrances shall be from either top or bottom. VFD's shall be located as shown on the Drawings.

2.3 OPERATIONAL DESCRIPTION

A. Operational sequences shall be as shown on the Drawings and described in the applicable Sections of Division 17000 and Division 11000 of these Specifications.

2.4 OPTIONAL VFD COMPONENTS

A. Furnish and install a Flygt MAS 801 monitoring system as specified and as indicated on the DRAWINGS. Coordinate with pump manufacturer.

B. Furnish contactor for motors over 50HP.

C. Furnish input reactors and output filters.

2.5 MANUFACTURER

A. The VFD's listed in this Division and in other Divisions shall be the product of one manufacturer. The VFD assembler shall be the manufacturer of the power inverter.

2.6 TRANSIENT CONDITIONS

A. The drives shall be capable of accepting a supply variation of 460 volts plus five percent or minus ten percent at 60 hertz plus or minus two hertz as a standard design feature.

B. The drives shall be of the diode bridge rectifier front-end type to minimize electrical noise generation and to operate at not less then 95 percent power factor over the full operating range.

C. For sustained or momentary power outages the drives shall have a safe shutdown design with automatic ramp-up return to normal operation, upon restoration of power.

D. For momentary voltage dips which shut down the drive, means shall be provided for automatic ramp-up return to full, controlled operation upon restoration of full line voltage.

2.7 ENVIRONMENT

A. The drive shall be capable of operating under any combination of the following conditions without mechanical or electrical damage:
   1. Ambient temperature: 0 to 50°C.
   2. Relative humidity: 0 to 95 percent non-condensing.
   3. Vibration: 0 to 0.5G.

2.8 CONTROL REQUIREMENTS

A. Current limit circuitry shall automatically phase back voltage and frequency to decrease current to 125 percent of the drive rated capacity.

B. The drive and inverter shall be UL listed and labeled by a nationally recognized testing laboratory.

C. The variable speed drive system shall include a diode bridge converter, filter network and a transistorized inverter section. Base driver signals used to control firing of the power transistors shall be designed with optically coupled isolators.

2.9 PROTECTIVE AND OPERATIONAL CHARACTERISTICS

A. The drives shall have the following protective and operational characteristics in addition to those previously described:
   1. Adjustable current limit.
   2. Overcurrent trip (125 percent).
   3. Short circuit trip (hall-effect current transformer).
   4. DC bus overvoltage trip.
   5. DC bus fuses.
   6. Line undervoltage trip (-30 percent) with automatic restart on voltage recovery.
   7. Momentary power failure trip (greater than ten milliseconds) with automatic restart.
   8. Line input 3-pole circuit breaker with current limiting fuses interlocked with the unit door. Circuit breaker shall be padlock able in the "OPEN" position.
   9. 4 to 20 mADC output signal proportional to speed.
   10. Motor contactor. Motor and power unit isolation circuit breaker or contactor as shown on the Drawings or described in the Specifications. Contactors shall be NEMA integral size. Half sizes and IEC rated contactors shall not be acceptable. NEMA dual rated contactors shall not be acceptable.
   11. By-pass contactor with overload relay with external or programmable reset where required by the Drawings. Contactors shall be NEMA integral size. Half sizes and IEC rated contactors shall not be acceptable. NEMA dual rated contactors shall not be acceptable.
   12. LED display of the following:
      a. Overcurrent trip at 125 percent.
      b. Internal component short circuit.
      c. Output short circuit.
      d. Overload (when soft stall not selected).
      e. Overvoltage on DC bus.
      f. Overvoltage on input.
      g. Undervoltage.
      h. Overheat.
      i. Ground Fault.
      j. Initial parameter mismatch.
      k. Frequency meter
      L. Run / Stop Indication
   13. Electronic motor overload relay.
   14. An internal microprocessor shall monitor the load on the drive and in the event of an overload it shall, based on the microprocessor's calculation of the true inverse time overload characteristic, either trip out or phase back the voltage and speed as selected by an internal jumper.
   15. Acceleration time: 1 to 20 seconds adjustable.

16. Dynamic braking: 12 percent standard.
17. Ramp to stop: 1 to 20 seconds adjustable.
18. Speed control integral to the programmable control module.
19. Local/Remote operation solid-state selector switch to be integral to the programmable control module. Provide a dry contact output from the programmable control module to indicate position of the Local/Remote switch.
20. Isolated contacts for remote indication of "RUNNING", “Computer Mode Selection”, VFD Fault and all other alarm conditions , as required by the Drawings.
21. Normal/bypass selector switch (for units with by-pass contactors) if feature is not available from the programmable control module.
22. Fault reset button on door if fault reset feature is not available from the programmable control module.
23. Input line reactor (inductor), three percent.
24. Output load filter.
25. Process follower to accept 4 to 20 mADC signal input.
26. Output signal of 4 to 20 mADC proportional to speed.
27. All additional devices as shown on the Drawings and specified herein.

B. The drive units shall be able to withstand phase-to-phase and phase-to-ground shorts without damage to the drive unit.

C. The drive shall include the solid-state features described above on plug-in circuit boards with microprocessor and on-board diagnostic circuitry with LED readouts as listed above.

D. The drive shall have integral transformers to supply all required control voltages including space heaters, where required. The control transformer and entire drive unit shall be de-energized when the line disconnect switch or circuit breaker is opened.

D. Fault trip conditions, except short time or momentary line voltage loss or line voltage momentary dip, shall lock out the control. Resetting of control after fault trip shall be manual by a door-mounted pushbutton.

F. Auto restart shall be a standard feature of the drive as follows:
   1. Auto restart shall be enabled or disabled by programming or jumper selection.
   2. On auto restart selection, the microprocessor shall determine, in the event of a fault, if a restart should be attempted. A restart shall be attempted under the following conditions:
      a. Undervoltage (UP): Every time as soon as voltage returns to a safe level. Fault relay shall not be activated.
      b. Input Overvoltage (OPS): Every time as soon as voltage returns to a safe level. Fault relay shall be activated for the duration of the high voltage condition.

c. Overcurrent (OC): Five attempts in 30 seconds. After the fifth OC, the drive shall trip out and latch the fault relay.

G. A restart shall not be attempted for any other type of fault and the drive shall trip out immediately, activate the fault relay, and make the information available on the programmable control module display until the drive is manually reset.

H. An undervoltage condition of less than 30 ms duration shall not affect drive operation. If main power falls below 85 percent of rated voltage for longer than 30 ms while control power is retained, the drive shall forcibly decelerate the load in an attempt to force a higher bus voltage through regeneration to allow the drive to "ride through" the undervoltage condition for up to 70 additional milliseconds for a total "ride through" of up to 100 ms for very high inertia loads. The manufacturer shall provide an option that allows control power to be maintained for 100 ms in the event of a power failure. If the drive drops out, it shall automatically restart upon restoration of full rated voltage, as previously described.

2.10 FACTORY TESTS

A. The testing procedure shall be the manufacturer's standard procedure to assure maintenance free service. The OWNER shall be given 14 days notice prior to start of factory testing so that the OWNER, at his option, may witness the testing.
   1. All final assemblies shall be tested at full load with application of line-to-line and line-to-ground bolted faults. The VFD shall trip electronically without device failure.
   2. After all tests have been performed; each VFD shall undergo an 8-hour burn-in test. The VFD's shall be burned in at 100 percent inductive or motor load for 8 hours without an unscheduled shutdown.
   3. After the burn-in cycle is complete, each VFD shall be put through a 30 minute cycling motor load test before inspection and shipping.
   4. Certification that all of the testing above has been performed shall be provided by the VFD manufacture, upon request.

B. All equipment, devices, instrumentation, and personnel required to perform the tests shall be supplied by the manufacturer. Upon satisfactory completion of the test, the manufacturer shall submit two certified copies of the test report to the ENGINEER. Component failure during testing will require repeating any test associated with the failure or modified components to demonstrate proper operation.

2.11 PAINTING

A. Units shall receive manufacturer's standard finish paint system prior to shipment.
B. Machined, polished, and non-ferrous surfaces shall be coated with corrosion prevention compound.

C. Painting shall conform to the requirements of Section 01600, General Equipment Provisions, and Section 09900, Painting.

D. All internally electronic components, devices terminations and other items shall be coated with an epoxy based conformal coating system.

PART 3 - EXECUTION

3.1 START-UP AND TEST

A. Make adjustments required to place system in proper operating condition.

B. A manufacturer's representative shall check and approve the installation before operation. He shall test operate the system in the presence of the ENGINEER and verify that the units conform to requirements. He shall revisit the jobsite as often as necessary until all trouble is corrected and the installation is entirely satisfactory.

3.2 MANUFACTURER'S SERVICES

A. A factory trained representative shall be provided for installation supervision, start-up and test services and operation and maintenance personnel training services. The representative shall make a minimum of three (3) visits, minimum eight (8) hours on-site for each visit, to the site. The first visit shall be for assistance in the installation of equipment. The second visit shall be for checking the completed installation and start-up of the system. The third visit shall be as described under Section 01821, Instruction of Operations and Maintenance Personnel. Manufacturer's representative shall test operate the system in the presence of the ENGINEER and verify that the variable frequency drives conform to requirements. Representative shall revisit the job site as often as necessary until all trouble is corrected and the installation is entirely satisfactory.

B. All costs, including travel, lodging, meals and incidentals, shall be considered as included in CONTRACTOR'S bid price.

++ END OF SECTION ++

SECTION 16442

LIGHTING, INSTRUMENTATION AND DISTRIBUTION PANELBOARDS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish and install lighting, instrumentation and distribution panelboards.
   2. Installation of new circuit breakers in existing panelboards shall be included in this Section and shall be rated as specified herein.

1.2 QUALITY ASSURANCE

A. Reference Standards: Comply with applicable provisions and recommendations of the following, except where otherwise shown or specified:
   1. NEC Article 408, Switchboards and Panelboards.
   2. NEMA PB1, Panelboards.
   3. NEMA 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
   4. UL Standard 50, Electrical Cabinets and Boxes.
   5. UL Standard 67, Electric Panelboards.
   6. UL Standard 698, Circuit Breaker Panelboard Assembly.
   7. UL Standard 943, Ground Fault Circuit Interrupters.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Manufacturer's technical information for panelboards proposed for use.
   2. Listing of the panelboards to be furnished with an identification of their proposed location, and number and rating of branch circuit breakers.
   3. Lighting, instrumentation and distribution panelboards load calculations.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Panelboards:
   1. Rating: Voltage rating, current rating, number of phases, number of wires and number of poles shall be as shown on the Drawings.
   2. Circuit Breakers: Molded case, bolt-in thermal magnetic type with number of poles and trip ratings as shown on the Drawings.

3. Main and branch circuit breakers shall be fully rated with interrupting capacities as follows:
   a. 65,000 amps for 480/277 volt circuit breakers.
   b. 22,000 amps for 120/240 volt circuit breakers.
4. Bus Bars: 98 percent conductivity copper, tin plated. All 4 wire panelboards shall have a solid neutral bar. All panels shall have ground bus.
5. Main: All panelboards shall have a main circuit breaker, unless Drawings specifically call for main lugs only.
6. Branch circuit breakers connected for sequence phasing.
7. Construction: Code grade steel, NEMA 12, ample gutter space, flush door, flush snap latch and lock for dry indoor locations. NEMA 4X stainless steel for outdoor or damp indoor locations.
8. Trim: Surface or flush, as required.
9. Directory: White card, minimum card stack 90 lb., maximum size 8" x 5", placed in a 9" x 5 ½" self adhesive vinyl pocket. Directory information to be a copy of the as-built panel schedule as provided on the contract drawings.
10. Identification: Factory installed manufacturer's nameplate identifying the panel number and voltage.
11. Product and Manufacturer: Provide panelboards of one of the following:
    a. To match existing

PART 3 - EXECUTION

3.1 INSTALLATION

A. Mounting: Install panelboards at locations shown on Drawings. Set cabinets so that top branch circuit breaker is not over six feet above the floor.

B. Arrange circuits to balance the loads on the panelboards.

+ + END OF SECTION + +

SECTION 16443

UNINTERRUPTIBLE POWER SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish and install Uninterruptible Power Systems (UPS).

B. Related Sections: CONTRACTOR shall coordinate the requirements of the Work in this Section along with the requirements of the Sections listed below which includes, but is not necessarily limited to, Work that is directly related to this Section.
   1. Section 16050, General Provisions.
   2. Section 16143, Disconnect Switches.
   3. Section 16141, Receptacles.

1.2 QUALITY ASSURANCE

A. Reference Standards: Comply with applicable provisions and recommendations of the following, except where otherwise shown or specified:
   1. NEMA 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
   2. UL 50, Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations.
   3. UL 67, Standard for Safety Panelboards.
   4. UL 943, Standard for Safety Ground Fault Circuit Interrupters.
   5. UL 1778, Standard for Safety Uninterruptible Power Systems.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Manufacturer's technical information for UPS proposed for use and all support racks, conduit, disconnect or other equipment needed to complete installation.
   2. Dimensioned drawings of the UPS in a floor plan to be furnished with an identification of their proposed location, and number and size of UPS.
   3. Electrical drawings and an updated Panel Schedule as needed to show circuit feeding UPS and connections from UPS to protected equipment. Including anticipated continuous electrical load calculations, backup time calculations and shall indicate the battery end-voltage used in the analysis.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Uninterruptible Power System:
   1. Uninterruptible Power System (UPS) shall be furnished to provide a reliable source of uninterruptible power with no break in AC output power during a complete or partial interruption of incoming line power. UPS shall include audio/visual alarms. UPS shall be UL listed.
   2. UPS shall be comprised of a static inverter, a precision hysteresis loop battery charger, sealed maintenance free batteries, a relay and bypass switch shall be contained in a single package.
      a. Use external bypass module manufactured by Eaton.
   3. Under normal operating conditions, the critical load shall be powered by normal AC line supply that has been filtered through a ferroresonant transformer. When AC line power is present, the inverter shall be normally off.
   4. When AC line power fails, the inverter shall supply AC power to the transformer from the battery source. There shall be no break in the output of the system during transfer from normal AC line supply to inverter battery supply or back to line. A single switch shall turn the system on and off. There shall also be an audible alarm disconnect switch.
   5. Output capacity shall be provided to meet the load of equipment furnished and include the following requirements.
      a. Backup Run Time: 15 minutes full load
      b. Input Voltage: 120 VAC, Output Voltage: 120 VAC.
      c. Voltage Regulation: ± Three percent nominal regulation.
      d. Efficiency: 85 percent on line at full load, 81 percent on inverter at full load.
      e. Wave Shape: Computer grade sine wave. Less than five percent THD.
      f. Frequency: 60 Hz ± 0.5 Hz.
      g. Noise Rejection: Common mode better than 120 dB. Transverse mode better than 60 dB.
      h. Isolation: Complete isolation from line with less than two pf of effective capacitance.
      i. Operating Temperature: 32 deg F to +104 deg F.
      j. Size: 5 kW minimum
   6. Maintenance Bypass/Isolation Switch Operation: Switch is interlocked so it cannot be operated unless the static bypass transfer switch is in the bypass mode. Device provides manual selection among the three conditions described below without interrupting supply to the load during switching:
      a. Service: Load is supplied, bypassing the UPS. Normal UPS ac input circuit, static bypass transfer switch, and UPS load terminals are completely disconnected from external circuits.
      b. Lines: Load is supplied, bypassing the UPS. UPS ac supply terminals are energized to permit operational checking, but system load terminals are isolated from the load.

c. UPS: Normal UPS ac supply terminals are energized and the load is supplied through the static bypass transfer switch and the UPS rectifier-charger and inverter, or the battery and the inverter.

7. Product and Manufacturer: Provide one of the following:
   a. Eaton/Powerware, Incorporated.
   b. or approved equal

PART 3 - EXECUTION

3.1 INSTALLATION

A. Mounting: Install UPS at locations shown on Drawings in accordance with manufacturers recommendations.

++ END OF SECTION ++

SECTION 16501

LIGHTING FIXTURES AND CONTROLS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish and install lighting fixtures and controls.

B. Coordination:
   1. Coordinate location of fixtures with piping, ductwork, openings and other systems and equipment and locate clear of interferences.
   2. Coordinate fixtures to be mounted in hung ceilings with the ceiling suspension system proposed for use.

1.2 QUALITY ASSURANCE

A. Reference Standards: Comply with applicable provisions and recommendations of the following, except where otherwise shown or specified:
   1. Illuminating Engineer's Society.
   2. National Electrical Code (NEC) current adoption.
   3. City of Phoenix – Amendments to the National Electrical Code.
   3. UL Standard No. 57, Electric Lighting Fixtures.
   4. UL Standard No. 844, Electric Lighting Fixtures for Use in Hazardous Locations.
   5. UL Standard No. 917, Clock-Operated Switches.
   6. UL Standard No. 1570, Fluorescent Lighting Fixtures.
   7. UL Standard #1571, Incandescent Lighting Fixtures.
   8. UL Standard #1572, High Intensity Discharge Lighting Fixtures.
   9. City of Phoenix Lighting Ordinance No. G2699 for Exterior Lighting.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Manufacturer’s catalog cuts and technical information for lighting fixtures proposed for use.
   2. Fixture construction details.
   3. ETL photometric and isocandle curves for each fixture proposed.
   4. Verification that recessed fixtures which are to be mounted in hung ceilings are compatible with the ceiling suspension system proposed for use.
   5. Manufacturer’s technical information for lighting controls proposed for use.

6. Wiring diagrams.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Type: Lighting fixtures are noted in the Fixture Schedule on the Drawings. Fixtures to be complete with supports, ballasts, lamps and incidentals, as required.

B. Lamps:
   1. Fluorescent: Cool white, energy efficient type.
   2. High Pressure Sodium: Color corrected.
   3. Light Emitting Diode (LED)
   4. Spare: Ten percent spare lamps of each type and wattage.

C. Ballasts:
   1. Fluorescent: High power factor, energy efficient type, equipped with thermal protectors (Type "P" ballast), compatible with the lamps installed.
   2. High Intensity Discharge: High power factor, constant wattage, stabilized autotransformer with line starting current the same or less than operating current.
   3. Ballasts to have "C" sound rating (min.) and be ETL/CBM certified.
   4. Spare: Ten percent spare ballasts of each type.

D. Fixtures located in an area which is identified as a hazardous location shall be approved as a complete assembly for the hazardous location classification as shown on the Drawings, shall be clearly marked to indicate maximum wattage of lamps for which they are approved, and shall be protected against physical damage by suitable guards.

E. Hardware: All necessary hangers, supports, conduit adaptors, reducers, hooks, brackets and other hardware required for safe fixture mounting shall be furnished. Hardware shall have a protective, non-corrosive finish.

F. Time Switch:
   1. Type: Astronomic dial time switch with day-omitting device.
   2. Timing Motor: Heavy duty, synchronous, self-starting, high torque, 120 volt or 277, 60 cycles, as shown on the Drawings.
   3. Capacity: 40 Amps per pole at 277 volts.
   4. Dial: 24 hour rotation, with gear to provide one revolution per year which automatically raises the ON and OFF settings each day according to seasonal changes of sunset and sunrise for the City of Phoenix, Arizona area.
   5. Reserve Power: Spring driven reserve sufficient to operate time switch contacts for a minimum of 30 hours after power failure. On restoration of power, time

switch shall transfer to synchronous motor drive and automatically rewind reserve.

6. Product and Manufacturer: Provide one of the following:
   a. Z Series by Tork Time Controls, Incorporated.
   b. Or equal.

G. Combination Lighting Contactors:
1. Rated 600 volts, 30 amps, electrically held number of poles as shown on the Drawings, housed in NEMA 12 enclosure.
2. Additional devices such as selector switches, circuit breakers, control power transformers, fuses, time clocks etc., as shown on the Drawings.
3. Product and Manufacturer: Provide one of the following:
   a. General Electric.
   b. Allen-Bradley.
   c. Or equal.

H. Photocell:
1. Cadmium sulphide hermetically sealed cell, fully temperature compensated, with time delay of at least 15 seconds to prevent false switching.
2. Built-in fail safe light level selector, adjustable within limits of 2 to 50 foot candles and factory set at 25 foot candles.
3. Product and Manufacturer: Provide one of the following:
   a. 2100 Series by Tork Time Controls, Incorporated.
   b. Or equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General: Fixture mounting heights and locations as shown on the Drawings are approximate and are subject to revision in the field, where necessary to clear conflicts and obstructions.

B. Suspended Fixtures: Pendant mount using 1/2-inch conduit stems. Ground to outlet box. Attach mounting to building structure with expansion anchors. Fixtures shall not be dependent on the outlet box cover screws for support.

C. Surface Mounted Fixtures: Attach to appropriate outlet box.

D. Boxes and Fixtures:
1. For units mounted against masonry or concrete walls, provide suitable 1/2-inch spacers to prevent mounting back of box directly against wall.
2. Bolt units rigidly to building with expansion anchors, toggle bolts, hangers or Unistrut.
3. No boxes shall be installed with open conduit holes.

4. Cable each circuit and identify with tag.

E. Mounting Heights: Mounting heights or elevations are to bottom of the fixture or to centerline of device.

F. Relamp all fluorescent fixtures with new lamps at end of construction period, prior to Final Completion of the new facilities by OWNER.

G. Mount equipment so that sufficient access and working space is provided for ready and safe operation and maintenance.

H. Mount photocell as shown on the Drawings and adjust footcandle setting for proper dusk and dawn photocontrol. Provide wiring in conduit from the photocell to controls.

I. Securely fasten equipment to walls or other surfaces on which they are mounted.

J. Install fixtures in conformance with Phoenix Electrical Code.

++ END OF SECTION ++

SECTION 17001

PROCESS CONTROL SYSTEM
GENERAL REQUIREMENTS

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Provide all labor, materials, equipment and incidentals as stated in the specified in the CONTRACT DOCUMENTS and install, calibrate, test, start-up, commission and place in satisfactory operation a complete Process Control System (PCS). PCS shall be as specified by Division 17, Process Controls Sections and all controls systems provided by others in all Divisions as specified on the CONTRACT DOCUMENTS.

B. The PCS is designed to control and monitor equipment operation and information. The unit processes, which the PCS shall control and monitor are shown and described in the CONTRACT DOCUMENTS.

C. EQUIPMENT SUPPLIERS are defined as suppliers or vendors who provide instrumentation, panels, equipment or services that interface with the PCS as specified in Division 17, Process Control System or other Divisions of the CONTRACT DOCUMENTS. EQUIPMENT SUPPLIERS shall coordinate with the PCS COORDINATOR (responsibilities as defined below).

D. OWNER shall configure/program all offsite (SCADA) (CCS) software. CONTRACTOR shall be responsible for all onsite PLC and OIT programming, onsite hardware configurations, onsite loop testing of signals, and communications testing for new and modified existing control equipment onsite through the offsite SCADA (CCS). CONTRACTOR shall use Black and Veatch for programming.

E. All control loops shall function as described in Section 17051, Process Control Descriptions or other Divisions and Drawings of the CONTRACT DOCUMENTS.

F. All instruments shall be field calibrated and witnessed by the ENGINEER as stated in Specification 17052 – Process Control System Primary Sensors and Field Instruments.

1.2 QUALITY ASSURANCE

A. General:
1. The CONTRACTOR shall acquire the services of a PCS COORDINATOR for coordination of the furnishing, approval, installation, testing, commissioning, and training for all aspects of the

PCS. The PCS COORDINATOR shall be the CONTRACTOR's representative for all subcontractors providing PCS equipment.

2. CONTRACTOR in conjunction with the PCS COORDINATOR shall be responsible for coordination and supervision of the supply, storage, installation, testing, startup, commissioning and training of all electrical equipment, instrumentation, panels and services defined in the CONTRACT DOCUMENTS to produce a fully functional PCS.
3. CONTRACTOR in conjunction with the PCS COORDINATOR shall be responsible for proper operation of the PCS with related equipment and materials furnished by other suppliers stated in the CONTRACT DOCUMENTS.

B. PCS COORDINATOR's Qualifications:
1. Have experience at designing, supplying, installing, testing, start-up and commissioning PCS's.
2. Have experience in coordinating, reviewing and the handling of equipment submittals.
3. Have experience with integration, implementation and have supported standard lines of digital and analog processing control instrumentation equipment.
4. Have working knowledge in hardware application, data highway systems and computer control systems software programming procedures.
5. Have experience in coordinating or providing standard training course offerings in general process control applications and in operation, programming and maintenance of the control systems and related equipment.
6. Have a thorough working knowledge of wastewater treatment processes and control philosophy in accordance with standard practices of the wastewater treatment industry.
7. Have thorough knowledge of relevant NEC, OSHA, MIL, NRC, ISA, SAMA, NFPA, UL and API standards and all relevant state and local codes.
8. Have experience in coordinating, reviewing, handling of and presenting equipment operations and maintenance training materials.

C. PCS COORDINATOR's Responsibilities:
1. General:
a.. Attend the Pre-Construction Conference as required in Section 01301 – Pre-Construction Conference for the presentation of the responsibilities of the PCS COORDINATOR.
b. Coordinate with the CONTRACTOR in the generation of the Progress Schedule as required in Section 01321 – Progress Schedule (CPM) to incorporate PCS construction activities into the Progress Schedule.

c. Attend the project Construction Progress Meetings required in Section 01312 – Progress Meetings.
d. Coordinate PCS Progress Meetings as described in Paragraph 1.3 below.
e. Maintain a punch list of items to be completed / corrected for the PCS. Provide an updated copy of this punch list to the ENGINEER at each construction progress meeting.

2. Reviews:
   a. Review CONTRACT DOCUMENTS (Specifications, P&ID's, Process Drawings, Electrical Drawings, Installation Details, etc,) and develop a list of concerns or problems noted for the completion of the complete operating PCS. Submit list to the ENGINEER prior to review of equipment submittals.
   b. Coordinate and review all PCS submittals and related equipment submittals in accordance with the CONTRACT DOCUMENTS, prior to submission of submittal to the ENGINEER. Complete Submittal Transmittal Form 01332-A included in Section 01331 – Reference Forms for inclusion with each submittal.
3. Installation:
   a. Verify delivery and proper storage of all PCS equipment per the requirements of Sections 01651 - Transportation and Handling of Materials and Equipment and 01661 – Storage of Materials and Equipment. Complete 01661-A - Equipment Delivery Inspection Report included in Section 01331 – Reference Forms for submittal to the ENGINEER.
   b. Supervise the installation of the CCS instruments, panels, consoles, cabinets, wiring and other components required.
   c. Coordinate with the CONTRACTOR in the development of all Maintenance of Plant Operations plans (MOPO's) affecting PCS equipment installation or activities as required in Section 01143 – Coordination with Owner's Operations.
   d. Coordinate proper interfacing of CCS hardware, software, field devices and panels, including required interfacing with packaged control systems furnished by other equipment suppliers, and with the plant electrical system.
4. Testing:
   a. Coordinate all calibration, testing, start-up and commissioning of the PCS as outlined in the Contract Documents.
   b. PCS COORDINATOR shall submit to the ENGINEER a schedule with proposed start dates and test procedure guidelines for start-up, commissioning and field testing at least four weeks in advance of the test start date. Prior to testing each process area, coordinate with the CCS VENDOR to insure that the installation of the CCS software, including any modifications and software configuration testing is completed prior to testing each process area.

c. Complete testing of each process loop through the CCS shall be documented by PCS COORDINATOR as listed in Section 17226 – Process Control System I/O list and submit the signed document to the ENGINEER upon successful completion of tests.
d. Coordinate all testing documentation in accordance with Section 01331, Reference Forms. Maintain a copy of Field Calibration Forms, Loop Test Forms, Equipment Test Reports, Loop Commissioning Forms, Factory Acceptance Test forms and other related forms from Section 01331 – Reference Forms in a single binder for submittal to the ENGINEER to be transmitted to the OWNER at the conclusion of the project.
e. Attend all factory tests required by Division 17 Specifications and other Division Specifications of the CONTRACT DOCUMENTS that are inclusive of the overall PCS.

5. Commissioning and Substantial Completion:
   a. Coordinate and provide review comments of all PCS Vendor Equipment Operations and Maintenance Manuals (VEOMM) prior to submission of manual to the ENGINEER. Complete Submittal Review Form 01781-B – Operations & Maintenance Data Review Checklist included in Section 01331 - Reference Forms for inclusion with each VEOMM submittal.
      1) Maintain a red-line of the VEOMM 's electrical drawings and schematics used during construction to reflect changes or deviations that occur during installation, start-up and commissioning for incorporation into the final VEOMMs. Submit the red-lined electrical drawings and schematics to the provider of the equipment for updates as VEOMM Record Documents for submittal to the ENGINEER to be transmitted to the OWNER prior to Substantial Completion of the project.
   b. Maintain red-line ISSUED FOR CONSTRUCTION DRAWINGS used during construction to reflect changes or deviations that occur during installation, start-up and commissioning for incorporation into the final Record Drawings. Submit the red-lined ISSUED FOR CONSTRUCTION DRAWINGS to the ENGINEER prior to Substantial Completion of the project.
   c. Coordinate and supervise training of OWNER'S personnel in operation and maintenance of the process control system as required in Division 17 Specifications and other Divisions of the CONTRACT DOCUMENTS as per Section 01821 – Instruction of Operations and Maintenance Personnel.

D. Reference Standards:
   1. The following organizations have generated standards that are to be used as guides in assuring quality and reliability of components and systems; govern nomenclature; define parameters of configuration and

construction, in addition to specific details in the CONTRACT DOCUMENTS.

a. ISA, The Instrumentation, Systems and Automation Society.
b. API, American Petroleum Institute.
c. UL, Underwriters' Laboratories, Inc.
d. AWWA, American Water Works Association.
e. Nuclear Regulatory Commission.
f. NEMA, National Electrical Manufacturers Association.
g. OSHA, Occupational Safety and Health Administration.
h. ANSI, American National Standards Institute.
i. MIL, Military Standards.
j. NFPA, National Fire Protection Association.
k. SAMA, Scientific Apparatus Manufacturers Association.
l. NFPA, National Fire Protection Association 79, Annex "D" Standards.
m. IEEE, Institute of Electrical and Electronic Engineers.
n. NEC, National Electrical Code.
o. FM, Factory Mutual.

1.3 COORDINATION AND PROGRESS MEETINGS

A. Schedule and coordinate the system installation with regard to all other Work on the site and in accordance with the provisions of the General Conditions. Said coordination shall be documented on the Project Schedule.

B. PCS coordination and progress meetings will be scheduled by the PCS COORDINATOR. The CONTRACTOR, ENGINEER, OWNER and appropriate EQUIPMENT SUPPLIERS shall be required to attend meetings during the time of active work on the PCS. A representative of the CCS VENDOR shall be required to attend meetings during the time of active work on the CCS. PCS COORDINATOR shall provide meeting minutes and updates to the project schedule.
   1. The purpose of the meetings shall be to review the progress of the Work involving the PCS and provide coordination for installation, testing, commissioning, and training of the equipment to ensure that the Project Schedule is met.
   2. Representatives at the meetings shall have the competence and authority to make any and all necessary decisions. Decisions and statements made at the meetings shall commit CONTRACTOR to agreed procedures and schedules.

1.4 SUBMITTALS

A. Shop Drawings:
   1. General:

a. Shop Drawing submittals are to be in accordance with the requirements of the CONTRACT DOCUMENTS and shall conform to the requirements of Section 01330 - Submittals and as required in other Division 17 Sections.
b. Manufacture or shipment of the PCS components shall not commence until related submittals have been reviewed by ENGINEER.
c. Shop Drawings shall be submitted in complete packages grouped to permit review of related items.
d. Review of Shop Drawings will be for conformance with CONTRACT DOCUMENTS and with regard to functions specified to be provided.

2. Submittal Requirements:
   a. Product information for all PCS equipment. Include the following:
      1) Manufacturer's product name and complete model number.
      2) Equipment CMMS Tag and loop number as provided in Section 01630 – Computerized Maintenance Management System Tags and from the CONTRACT DOCUMENTS.
      3) Manufacturer's data sheets and catalog literature. Provide data sheets as shown in ISA-20-1981. For instruments not included in ISA-20, submit data sheets using a similar format.
      4) Description of construction features.
      5) Performance and operation data.
      6) Installation and mounting details, instructions and recommendations.
      7) Service requirements.
      8) Dimensions.
      9) List of recommended spare parts.
      10) UL/UR Listing Numbers.
      11) Electrical control schematics and field wiring diagrams
      12) Ranges and set points of field and control panel instruments
   b. Control Panel Information:
      1) Control panels shall be furnished in accordance with the requirements as shown on the Drawings and as specified in Division 17000, Sections 17051 – Process Control Descriptions, 17226 – Process Control System I/O List, 17260 – Control Panels, 17262 – Programmable Logic Controller, Software and Programming and Division 16000, Section 16050 – General Conditions.
   c. OPTO 22 Cabinets:
      1) OPTO 22 Cabinets shall be furnished in accordance with the requirements as shown on the Drawings and as specified in Division 17000, Section 17261 – OPTO 22 Cabinets.

B. System Operation and Maintenance Manuals:

1. Furnish Operations and Maintenance Manuals for the PCS in accordance with Section 01781, Operation and Maintenance Data.

C. Report Forms:
1. Four (4) copies of the Field Calibration Forms, Loop Test Forms, Equipment Test Reports, Loop Commissioning Forms, Factory Acceptance Test forms and other related forms from Section 01331 – Reference Forms shall be submitted to the PCS COORDINATOR.

1.5 EQUIPMENT DELIVERY, HANDLING AND STORAGE

A. Comply with the requirements of Section 01651, Transportation and Handling of Materials and Equipment and Section 01661, Storage of Materials and Equipment.

B. All arrangements for transportation, delivery and storage of the equipment and materials to be in accordance with the requirements of the CONTRACT DOCUMENTS and the requirements of equipment manufacturers.

C. PCS equipment shall be packaged at the factory prior to shipment to protect each item from damage during shipment and storage. Containers shall be protected against impact, abrasion, corrosion, discoloration or other damages. Clearly label contents of each container and provide information on the required storage conditions necessary for the equipment. Keep OWNER and ENGINEER informed of equipment delivery.

D. All equipment shall be handled and stored in accordance with manufacturer's instructions and relevant organization standards. Equipment shall be protected from weather, moisture and other conditions that could cause damage. Items that require a controlled environment for storage such as panels and microprocessor units shall be stored in a climate controlled warehouse or facility. EQUIPMENT SUPPLIER shall notify CONTRACTOR and PCS COORDINATOR, in writing, with copies to OWNER and ENGINEER of the storage requirements and recommendations for the equipment prior to shipment.

E. Provide shop as-built control panel drawings upon delivery of the control panel.

1.6 GENERAL REQUIREMENTS

A. Power Supplies:
1. All electrically powered equipment and devices shall be suitable for operation on 115-volt 60 Hz power. If a different voltage, a suitable transformer shall be provided if approved by ENGINEER and OWNER.
2. Appropriate power supplies shall be furnished by CONTRACTOR for all two wire transmitters, loops for monitoring discrete inputs and all necessary outputs.

3. Power supplies shall be mounted in enclosures and installed in the appropriate control room or field panel.
4. Design all power supplies for a minimum of 130 percent of the maximum simultaneous current draw.

B. Signal Requirements:
1. The control system shall be designed to use 4 to 20 mADC analog signals, unless otherwise specified.
2. Provide signal converters and repeaters, where required. In addition, analog inputs to the computer control system shall be through appropriate repeaters to provide signal isolation where series looped with other devices, and to allow the loop to maintain integrity even if the CCS is out of service. Power supplies shall be sized adequately for signal converter and repeater loads.
3. Signals shall be isolated from ground.
4. The system and associated input/output wiring will be used in a plant environment where there can be high energy AC fields, DC control pulses, and varying ground potentials between the sensors/transducers or input contact locations and the system components. The system design shall be adequate to provide proper protection against interferences from all such possible situations.

C. Miscellaneous:
1. All instrumentation and PCS components shall be heavy-duty types, designed for continuous service in a municipal wastewater treatment plant environment. The system shall contain products of a single manufacturer, where possible, and consist of equipment models, which are currently in production. All equipment provided shall be of modular construction and be capable of field expansion through the installation of plug-in circuit cards and additional cabinets as necessary.
2. Design all logic and control loops to fail-safe. Fail-safe is to protect system if a field wire becomes disconnected.
3. All field-mounted instruments and PCS components shall be designed for installation in humid and corrosive service conditions. All field mounted instrument enclosures and appurtenances shall conform to NEMA ratings listed in Division 16000, Section 16050 – General Requirements, unless otherwise specified.
4. Ranges and scales specified herein shall be coordinated to suit equipment actually furnished.
5. Field-mounted devices shall be protected from exposure to freezing temperatures and shaded from direct sunlight.

D. Environmental Conditions:
1. The control system shall be designed and constructed for continuous operation under the following temperature and humidity conditions:
a. Control Rooms:

1) Ambient Temperature: 60°F to 80°F normal range; 40°F to 105°F occasional maximum extremes.
2) Relative Humidity: 80 percent, normal; 95 percent maximum.

b. Indoor locations for digital processing equipment hardware, control panels and instruments:
1) Ambient Temperature: 40°F to 120°F.
2) Relative Humidity: 98 percent maximum.

c. Outdoor locations for instruments:
1) Ambient Temperature: -10°F to 131°F.
2) Relative Humidity: 100 percent maximum.

E. System Designs:
1. Range, scale and setpoint values specified in other Division 17, Process Control System Sections are for initial setting and configuration. Modifications to these values may be required based on actual equipment furnished and as necessary to implement proper and stable process action and that is determined as systems are placed in operation. These modifications shall be done at no additional cost to OWNER.
2. For any items where ranges, scales and setpoints may not have been specified, CONTRACTOR shall submit a recommendation to ENGINEER for review.

1.7 SYSTEM START-UP, COMMISSIONING AND FIELD TESTING

A. Comply with the requirements of Section 01752 – Equipment and System Start-up and Performance Testing and include the additional requirements:
1. Provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish and install all equipment and coordinate all activities required to perform start-up, commissioning and field testing of the Process Control System. Field testing shall include an integrated system field test and operational availability demonstration.
2. Retain the services of the EQUIPMENT SUPPLIERS and CCS VENDOR to supervise and/or perform start-up, commissioning and field testing of all system components. As part of these services, the EQUIPMENT SUPPLIERS shall include for the equipment items not manufactured by the EQUIPMENT SUPPLIER, the services of an authorized manufacturer's representative to check the equipment installation and place the equipment in operation. The manufacturer's representative shall be thoroughly knowledgeable about the installation, operation and maintenance of the equipment.

B. System Check-Out and Start-Up
1. With the aid of the EQUIPMENT SUPPLIERS, responsibility belongs to CONTRACTOR to perform the following:

a. Check and approve the installation of all computer control system components and all cable and wiring connections between the various system components prior to placing the various processes and equipment into operation. Check-out shall include the following items as a minimum:
   1) All wiring shall be checked at each termination point for correct wire size, type, color, termination and wire number.
   2) Analog wiring shall be checked for correct polarity and ground continuity at each termination point in the loop.
   3) All control and monitoring loops shall be checked for signal continuity from source (such as field instrument/equipment, control panel, etc) to end destination.

b. Conduct a complete system checkout and adjustment, including calibration of all instruments, tuning of control loops, checking operation functions, and testing of final control actions. When there are future operational functions included in this Work, they should be included in the system checkout. All problems encountered shall be promptly corrected to prevent any delays in start-up of the various unit processes.

c. All instruments and devices shall be checked to verify compliance with the Specifications and approved Shop Drawings.

2. Provide all test equipment required to perform the testing and field calibration of instruments during system checkout and start-up.

3. Furnish to the ENGINEER certified calibration reports provided in Section 01331, Reference Forms for field instruments and devices as soon as calibration is completed. Factory calibrations are not acceptable as a replacement for field calibrations. All instruments must be field calibrated and witnessed by the ENGINEER and OWNER.
   a. Receipt of any calibration certificate shall in no way imply acceptance of the work or instrument.
   b. Each calibration certificate shall be signed and dated by an authorized representative of CONTRACTOR. Three copies of each completed certificate shall be submitted to ENGINEER.

4. Furnish to the ENGINEER two copies of an installation inspection report 01620-A - Manufacturer's Installation Certification Form in Section 01331 – Reference Forms certifying that all equipment has been installed correctly and is operating properly. The report shall be signed by authorized representatives of both CONTRACTOR and the EQUIPMENT SUPPLIER.

5. All spare parts must be on-site and accepted prior to commencing integrated system field tests.

C. Commissioning

1. Following the Process Control System checkout and initial operation, CONTRACTOR, with the aid of the EQUIPMENT SUPPLIERS and CCS VENDOR, perform a complete system test in the presence of the

ENGINEER to verify that all equipment is operating properly as a fully integrated system, and that the intended monitoring and control functions are fully implemented and operational.

a. Commissioning can only begin when all instruments and control panels are installed and wired. Operation and Maintenance manuals and a schedule for training must be approved prior to Commissioning.
b. All spare parts must be on-site and accepted prior to Commissioning.
c. Submit to the ENGINEER a schedule for Commissioning, including a proposed start date and Commissioning test sheet examples at least three weeks in advance.

2. Commissioning shall exercise field signals between field equipment or instrumentation and each Input/Output Panel though the CCS's workstation graphic display. As a minimum, perform the following checks for each test:
   a. All wiring shall be checked at each termination point for correct wire size, type, color, termination and wire number.
   b. All instruments and devices shall be checked to verify compliance with the Specifications and approved Shop Drawings. The calibration of analog devices shall be verified including the zero and span.
   c. Analog wiring shall be checked for correct polarity and ground continuity at each termination point in the loop.
   d. All analog loops shall be verified at each termination point at 0%, 25%, 50%, 75% and 100% signal levels.
3. Provide the following documentation for use during the Commissioning effort.
   a. Complete panel schematic and internal point-to-point wiring interconnect drawings.
   b. Complete electrical control schematics.
   c. Complete panel layout drawings.
   d. Complete field wiring diagrams.
   e. Complete instrument loop diagrams.
   f. Completed calibration certificates for all field and panel devices which require adjustment and/or calibration.
   e. Provide one set of Commissioning documentation for the OWNER'S personnel, one set for the ENGINEER'S use, one set for field use, and the required number of sets for CONTRACTOR'S use.
4. The Drawings corrected and modified during Commissioning shall form the basis for the "As-Built" Record Drawing requirement as specified in this Section.
5. Any defects or problems found during the Commissioning effort shall be corrected by CONTRACTOR and then retested to demonstrate proper operation.

D. Integrated System Field Test
   1. Following the completion of Process Control System checkout and initial operation and CCS software testing the CONTRACTOR, with the aid of the EQUIPMENT SUPPLIER and CCS VENDOR, shall remain on-site and be available during this period to correct instrumentation and control system hardware problems. The integrated field test shall be performed to verify all equipment/instrumentation is operating properly as a fully integrated system with the CCS, and that the intended monitoring and control functions are fully implemented and operational.
   2. Following software testing and demonstration of all system functions, the Process Control System including field sensors/transducers and instruments shall be running and fully operational for a continuous 48 hour period. The Operational Availability Demonstration specified below shall not begin until the continuous 48 hour integrated system test has been successfully completed and OWNER and ENGINEER agree that the Operation Availability Demonstration can begin.
   3. Any defects or problems found with the instrumentation, control system hardware, control panel components/wiring and field devices during the integrated field testing effort shall be corrected by CONTRACTOR and then retested to demonstrate proper operation.

1.8 PROCESS CONTROL SYSTEM TRAINING

A. Requirements and Responsibilities
   1. Provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to perform and coordinate all required training at times acceptable to OWNER and ENGINEER.
   2. Retain the services of all PCS EQUIPMENT SUPPLIERS to provide operation and maintenance training for all Process Control System equipment as specified herein.
   3. For equipment items not manufactured by the EQUIPMENT SUPPLIERS, the EQUIPMENT SUPPLIER shall provide for on-site training by an authorized representative of the equipment manufacturer as part of the Supplier's services. The manufacturer's representative shall be fully knowledgeable in the operation and maintenance of the equipment.
   4. Responsibility for all costs associated with training both on-site and at the EQUIPMENT SUPPLIER'S facilities, including all required materials, texts and required supplies, belongs to CONTRACTOR.
   5. All training shall be conducted in the normal eight hour working days until conclusion of the training course.

B. Submittals
   1. Submit training plans conforming to the requirements of Section 01821, Instruction of Operations and Maintenance Personnel. Included in the

plan shall be course outlines and schedules for training to be provided at the EQUIPMENT SUPPLIER'S facilities.

C. On-Site Training
   1. Training Covering the Control Equipment:
      a. The EQUIPMENT SUPPLIERS shall provide twenty four (24) hours of operations training covering all system components.
      b. Training course shall accomplish the following:
         1) Provide all instructions required to operate and utilize all system components.
         2) Provide all instruction required to monitor and control the system processes from the designated control panel.
         3) Explain procedures for control of the system during scheduled or rescheduled shutdown and the subsequent start-up.
         4) Provide instructions for routine preventative and troubleshooting maintenance.
   2. CCS Training:
      a. The CCS VENDOR shall provide twenty four (24) hours of training that covers the CCS as follows:
         1) Provide an overview of system hardware and software.
         2) It shall train people in configuration, operation and programming the CCS.
         3) The emphasis shall be placed on how to perform set point changes, minor programming changes, range changes, diagnostics and upkeep of documentation.
         4) Instruction for hardware and software maintenance, troubleshooting and maintenance planning.

PART 2 - PRODUCTS

2.1 GENERAL

A. All materials or products which can contact drinking water or a water treatment chemical furnished and installed under this division shall require NSF/ANSI 61, Drinking Water System Components Health Effects, approval or comply with Arizona Administrative Code R18-4-213, Standards for Additives, Materials, and Equipment.

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 17051

PROCESS CONTROL DESCRIPTIONS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section describes all of the anticipated control strategies under this Contract. The required control strategies for the various unit operations is a combination of the representation shown on the CONTRACT DRAWINGS and the requirements specified herein. The CONTRACT DRAWINGS do not show all the required internal diagnostic indications. In addition to the signals shown on the CONTRACT DRAWINGS, the following process control descriptions shall be provided, as a minimum:
   1. Analog Signals:
      a. Analog signals shall be 4 to 20 mADC unless otherwise stated.
      b. Analog signals that are connected to multiple devices in the loop shall be wired in series unless otherwise stated in the loop description.
      c. Loop power for all analog instruments shall be provided in the Local Control Panel (LCP) or Motor Control Panel (MCP). If there is no LCP or MCP, loop power shall be derived from the Computer Control System - Remote Input/Output Panels (RIO)
   2. Discrete Signals:
      a. Discrete signals for all field wires shall be designed to be fail safe.
         1) If a field wire for a control circuit device fails the equipment should be designed to shut down.
         2) If a field wire for an alarm circuit fails, the alarm shall be activated.
   3. Indication of a communications failure between any of the Programmable Logic Controllers (PLC) with the respective Computer Control System Field Control Unit (FCU) shall be programmed as an alarm in the Computer Control System. The broken communications link must be identified individually to assist in troubleshooting.
   4. Indication of a power failure at any of the PLC's and/or FCU panels shall be programmed as an alarm in the Computer Control System and identified individually to assist in troubleshooting.
   5. Mismatch alarms for all motorized equipment (e.g., pumps and gates, etc.). If the status feedback does not agree with the command after a time delay, annunciate the alarm in the Computer Control System.
   6. Runtimes shall be programmed in the Computer Control System for all pieces of equipment unless elapse Time meters are shown on the P&ID’s or listed in the loop descriptions.

7. Digital and analog signals provided from Vendor supplied equipment that are not shown on the CONTRACT DRAWINGS but are provided by the Vendor shall be verified and incorporated into the control systems.

B. The process control descriptions are written descriptions of the basic configuration and/or programming required to implement the sequential control of the unit processes shown on the CONTRACT DRAWINGS and as specified. The control descriptions do not, in all cases, describe the process characteristics fully. Finalizing and tuning of strategies, as required, by the process characteristics shall be accomplished during start-up. **In addition, the process control descriptions do not include existing equipment. Contractor shall reverse engineer all existing programs as needed to furnish a complete functioning Lift Station for both replaced and existing equipment or as a turnkey system. Contractor shall remove alarms that currently go to the existing Cave Creek WWTP in the software such that no alarms will need to be reset at the Cave Creek WWTP.**
The OIT added to this project shall be programmed to include all points associated with the pump station facility. Control and monitoring of all pump station facility equipment shall be in accord with City of Phoenix requirements.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 Sewage Lift Pump Station

Lift Station 66 operates solids handling submersible pumps in a wet well to pump raw wastewater to force mains. The rehabilitated lift station will consist of 4 new lift pumps. Two lift pumps shall be operated under normal conditions as need in automatic mode of operation to maintain a system wetwell level setpoint. The other two pumps will be used as a backup when a pump is faulted or out of service. When the site PLC is not operational, a backup control panel will control the lift pumps based on wetwell level. A biofilter system is used for odor control and is manually operated at the local control panels. The system is monitored only by the site PLC.

A. Sewage lift pumps:
General:
- When two pumps are running, only one pump shall run from each wetwell compartment. Two pumps from the same wetwell compartment is not permitted since each wetwell will be piped to a dedicated forcemain (West wetwell goes to South forcemain and East wetwell goes to North forcemain). Two pumps pumping through a single force main is not acceptable. For example:

- Pump P-101 and P-102 (West wet well pumps) should not operate at same time.
- P-103 and P-104 (East wetwell pumps) should also not operate at the same time.
- The lag pump must be a pump that is located in the other side of the wetwell opposite to the lead pump currently selected.

1. Local manual mode of operation: When the pump VFD is selected for local mode of operation at the VFD using the VFD keypad, the pump can be started, stopped, and speed controlled using the VFD keypad.
2. Remote mode of operation: When the pump VFD is selected for remote mode of operation at the VFD using the VFD keypad, and the backup mode is selected for PLC control at LCP-BACKUP-LS66, the pumps will be automatically started, stopped, and speed controlled by the PLC and OIT. When the level in the wetwell (Always use the highest level of the two level transmitters in the respective wetwell) rises above an operator adjustable system level setpoint and after a time delay, the pump with the lowest runtime (Lead pump) will start and run and automatically speed adjust to maintain the level setpoint. If the lead pump speed is at maximum and the level is below the system level setpoint for a time delay, a pump with the next lowest runtime (Lag pump) will start and run and automatically speed adjust to maintain the system level setpoint. This process will continue as needed to maintain the system level setpoint. When the level is below the system level setpoint, and the pumps are running at minimum speed, and after a time delay, the lag pump will stop and the logic will check if the lead pump is running at min speed, and the level is less than the system level setpoint, and after a time delay, will stop the lead pump. This process will continue as needed to maintain the system level setpoint. If a pump is called to run but is out of service or faulted, the pump with the next lowest run time in the respective wetwell, will take its place. Pump lead\lag selection should have an automatic and manual mode. If automatic, the lead\lag is based on pump runtime. If in manual, the operator can select a fixed lead and lag pump. If the backup mode is selected for local mode at LCP-BACKUP-LS66, the pumps shall not be controlled by the PLC but rather will run at a fixed speed when manually selected at the LCP-BACKUP-LS66 panel and when the respective level transmitter calls for the pump. A pump will not run if there is a respective alarm in the MAS801 system or if the pump's discharge valve is not fully open or if the disconnect switch is not closed or if the VFD is faulted.

C. Biofilter System:
   1. The signals indicated in the contract drawings shall be monitored and displayed as indicated on the P&IDs. There are no control signals form the site PLC for this system.

D. Flow Transmitters:
   1. The signals indicated in the contract drawings shall be monitored and the flow total signals shall be used to totalize flow in the site PLC and used for display.

E. Pressure Transmitters:
   1. The signals indicated in the contract drawings shall be monitored and displayed. High discharge pressure shall be created in the site PLC and shall be displayed for alarming purposes.

F. Pump Discharge Electrically Actuated Eccentric Plug Valves:
   1. The signals indicated in the contract drawings shall be monitored and displayed. Remote control is manual. When the valve is selected for local mode at the valve actuator, the valve can be manually opened and closed at the valve actuator. When the valve is selected for remote mode at the valve actuator, the valve can be remotely opened and closed. Automatic mode is not required.

+ + END OF SECTION + +

SECTION 17052

PROCESS CONTROL SYSTEM
PRIMARY SENSORS AND FIELD INSTRUMENTS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals as shown, specified and required to furnish, install, calibrate, test, adjust, commission and place into satisfactory operation all primary sensors and field instruments furnished under this Section.
   2. Contract Documents illustrate and specify functional and general construction requirements of the sensors and field instruments and do not necessarily show or specify all components, wiring, piping and accessories required to make a completely integrated system. Provide all components, piping, wiring, accessories and labor required for a complete, workable and integrated system.

B. Coordinate the installation of all items specified herein and required to ensure the complete and proper interfacing of all the components and systems.

1.2 QUALITY ASSURANCE

A. Comply with the requirements of Section 17001, Process Control System General Requirements for Process Instrumentation.

B Acceptable Manufacturers:
   1. Furnish primary sensors and field instruments by the named manufacturers.
   2. Obtain all sensors and field instruments of a given type from the same manufacturer.

C. Manufacturers' Responsibilities and Services:
   1. Design and manufacture the primary sensors and field instruments in accordance with the applicable general design requirements specified in Section 17001, Process Control System General Requirements for Process Instrumentation, and the detailed Specifications herein.
   2. Field supervision, inspection, and start-up in accordance with the requirements of Section 17001, Process Control System General Requirements.

1.3 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Comply with the requirements specified in Section 17001, Process Control System General Requirements for Process Instrumentation.

B. Primary sensors and field instruments shall not be delivered to the site until all product information and Shop Drawings for the sensors and instruments have been approved by ENGINEER.

1.4 SUBMITTALS

A. Comply with the requirements specified in Section 17001, Process Control System General Requirements for Process Instrumentation.

1.5 CHEMICAL SERVICE

A. Where a primary element is designated for chemical service, all wetted components and appurtenances for that primary element shall be resistant to corrosion by that chemical. Chemicals referred to commonly as "caustic", "sodium hypochlorite", "hydrochloric acid", "ferric chloride", and "methanol" shall mean the following:
   1. "CAUSTIC": Sodium hydroxide (NaOH), 50 percent solution, Specific Gravity = 1.53.
   2. "SODIUM HYPOCHLORITE": Sodium Hypochlorite (NaOCl), 15 percent solution, Specific Gravity = 1.23.
   3. "HYDROCHLORIC ACID": Hydrochloric Acid (HCl), 38 percent solution, Specific Gravity = 1.4.
   4. "FERRIC CHLORIDE": Ferric Chloride (FeCl3), 43 percent solution, Specific Gravity = 1.46.
   5. "POLYMER": Polymer Solution, 0.2 to 0.5 percent solution, Specific Gravity = 1.00.
   6. " METHANOL": Methanol (CH3OH), 99 percent solution, Specific Gravity = 0.792.

1.6 MATERIALS OF CONSTRUCTION FOR WETTABLE PARTS

A. Provide the following materials of construction for primary sensors and field instrument (wetted) parts that come in contact with the following list of process fluids:

PROCESS FLUID	ELASTOMER	METAL	PLASTIC	OTHER
Air		Type 316 SS	Teflon	
Alum	Buna-N	Type 316 SS		
Ammonia		Type 316 SS	Teflon	
Carbon	Buna-N	Type 316 SS		
Chemical Sump Drainage			Teflon Polypropylene	
Chlorine Gas or Liquid	Viton	Hastelloy C, Monel, or Tantalum		
Digester Gas	Viton	Alloy C276 Type 316 SS		
Ferric Chloride		Tantalum	Teflon Polypropylene	Ceramic
Fluoride	Viton	Hastelloy C		
Glycerine Oil	Neoprene Viton Buna-N	Type 316 SS	Teflon Polypropylene PVC/CPVC	
Halocarbon	Neoprene	Type 316 SS	Teflon	
Hydrochloric Acid	Viton	Tantalum Zirconium Platinum	Teflon	Ceramic
Lime		Type 316 SS	Teflon	
Methanol		Type 316 SS	Teflon	
Non Potable Water	Neoprene	Type 316 SS	Teflon	Ceramic

PROCESS FLUID	ELASTOMER	METAL	PLASTIC	OTHER
Odor Control Scrubber Solution		Platinum	Teflon Tefzel	Ceramic
Polymer	Buna-N	Type 316 SS		
Potassium Permanganate	Viton	Carpenter 20		
Raw Sewage	Viton	Type 316 SS	PTFE Polypropylene	
Sodium Chloride			Teflon	
Sodium Hydroxide		Hastelloy B Zirconium Platinum	Teflon Polypropylene PVC/CPVC	Ceramic
Sodium Hypochlorite		Hastelloy C Tantalum Titanium Platinum	Teflon PVC/CPVC Kynar	Ceramic
Silicone Oil	Viton Buna-N	Type 316 SS	Teflon Polypropylene	
Sludge	Neoprene Buna-N	Type 316 SS	PTFE	Ceramic

1.7 IDENTIFICATION TAGS

A. All sensors and field instruments shall have an identification tag conforming to the following requirements:
   1. Provide CMMS Tags for all instruments as specified under Section 01630, Computerized Maintenance Management System Tags.

1.8 SUNSHADES

A. Instruments and analyzers installed outdoors shall be firmly supported and protected by sun / rain shades, as specified or shown on DRAWINGS.
   1. Product and Manufacturer: Provide one of the following:
      a. Obrien – VIPAK
      b. Alumaline
      c. Or Equal

PART 2 PRODUCTS

2.1 PROCESS TAPS, SENSING LINES AND ACCESSORIES

A. Water Pressure Sensing Lines and Accessories for Flow and Pressure Transmitters:
   1. Material: Type 316 stainless steel; .049 wall thickness.
   2. Pressure Rating: 250 psi.
   3. Size: 1/2-inch outside diameter or as shown on the Drawings.
   4. Connections: Type 316 stainless steel compression type, "Swagelok", as manufactured by Crawford.
   5. Shut-off Valves:
      a. Type: Full port ball.
      b. Pressure Rating: 250 psi.
      c. Body, Ball and Stem: Type 316 stainless steel.
      d. Packing: High Density TFE.
      e. Handle: Nylon with metal travel stops.
      f. Support Rings: Stainless steel.
      g. End Connections: Removable "Swageloks".
      h. Product and Manufacturer: Provide one of the following:
         1) 45 Series, as manufactured by Whitey.
   6. Manifolds:
      a. Type: Five valve and three valve meter manifolds.
      b. Materials: Type 316 stainless steel body, bonnets and stems, delrin seats, Teflon packing.
      c. Product and Manufacturer: Provide one of the following:
         1) Whitey.
         2) Anderson-Greenwood

B. Air Pressure Sensing Lines and Accessories for Air Flow/Pressure Transmitters:
   1. Material: Type 316 stainless steel tubing, ASTM A 269, .049 wall thickness.
   2. Pressure Rating: 250 psi.
   3. Size: 1/2-inch outside diameter or as shown on the Drawings.
   4. Connections: Type 316 stainless steel compression type, "Swagelok" as manufactured by Crawford.
   5. Shut-off Valves:
      a. Type: Full port ball.
      b. Pressure Rating: 250 psi.
      c. Body, Ball and Stem: Type 316 stainless steel.
      d. Packing: High density TFE.
      e. Handle: Nylon with metal travel stops.
      f. Support Rings: Stainless steel.
      g. End Connections: Removable "Swageloks"
      h. Product and Manufacturer: Provide one of the following:
         1) 43 Series, as manufactured by Whitey.

6. Manifolds:
   a. Type: Five valve and three valve meter manifolds.
   b. Materials: Type 316 stainless steel body, bonnets and stems, delrin seats, teflon packing.
   c. Product and Manufacturer: Provide one of the following:
      1) Whitey.

C. Pressure Tap Sensing Lines and Accessories for Pressure Gages and Pressure Switches:
   1. For Process Sensing Taps in Ductile Iron, Steel and Stainless Steel Piping Systems:
      a. Material and Fittings: Type 316 stainless steel pipe (ASTM A 312) and threaded fittings and adapters (ASTM A 403) in accordance with Section 15103, Stainless Steel Pipe.
      b. Sizes: ½-inch minimum for main sensing piping and ¼-inch gage and switch connections or as shown on the Drawings.
      c. Pressure Rating: Equal to or greater than the applicable system test pressure as specified in Section 15050, Piping Systems.
      d. Accessories:
         1) For applications not requiring diaphragm seals, provide separate ¼-inch Type 316 stainless steel threaded gage cocks for each gage and switch.
         2) For applications requiring diaphragm seals, provide a separate 1/2-inch threaded Type 316 stainless steel ball valve for seal process side shutoff for each gage and switch. Ball valves shall be provided in accordance with the requirements of Section 15115, Ball Valves, Operators and Appurtenances.
   2. For Process Sensing Taps in Copper and Thermoplastic Piping Systems:
      a. Pipe Material and Fittings: Use same type of pipe material and fittings as that used in the process piping system. Copper pipe and fittings shall be provided in accordance with the requirements of Section 15105, Copper Pipe. CPVC pipe and fittings shall be provided in accordance with the requirements of Section 15106, Thermoplastic Pipe.
      b. Sizes: 1/2-inch minimum for main process sensing piping and for gage and switch connections.
      c. Pressure Rating: Equal to or greater than the applicable system test pressure as specified in Section 15050, Piping Systems.
      d. Accessories:
         1) For copper piping system taps with or without seals, provide a separate ¼-inch minimum threaded brass or bronze gage cock for each gage and switch.
         2) For CPVC piping systems with or without diaphragm seals, provide a separate 1/2-inch threaded ball valve for process sensing line shutoff for each gage and switch. Ball valves shall be provided in accordance with the requirements of

Section 15113, Thermoplastic Valves, Operators and Appurtenances.

2.2 INSTRUMENTATION

INSTRUMENT TYPE F1 - MAGNETIC FLOWTUBE AND TRANSMITTER

A. Functions:
   1. Flowtube: Produce low level, high impedance pulsed DC signal proportional to the rate of fluid flow using the principle of electromagnetic induction.
   2. Pulsed DC Magnetic Flow Transmitter: Drive the flowtube coils with pulsed DC power and convert the flowtube output signal into a DC current output linear to the flow rate.

B. System (Flowtube and Transmitter) Performance Requirements:
   1. System Accuracy (with Analog Output): ±0.5 percent of flow rate or better over range from 1 fps to 31 fps; ±.005 fps or better at flows below 1 fps flow range. System accuracy shall be proven by submittal of flow test curves of the actual meters being furnished. Test curves shall show a minimum of three flow points. Tests shall be performed using water and a weight or volume tank. A "Master Meter" used, as a reference standard is not acceptable. The test setup shall be submitted and approved prior to testing.
   2. System Repeatability: ±0.15 percent of flow rate or ±.0015 fps, whichever is greater.
   3. Drift: Complete zero stability.
   4. Minimum Fluid Conductivity Limit: Five microsiemens per centimeter or less.
   5. Fluid Property Effects: Accuracy unaffected by changes in fluid velocity, density, pressure, temperature or conductivity (above minimum conductivity limits).

C. Transmitter:
   1. Output: 4 to 20 mADC, direct acting and isolated, into 0 to 700 ohms.
   2. High accuracy, field adjustable scaled pulse output (2 to 800 Hz or greater) to drive local totalizer and provide scaled pulse output with a durations width of 0.5ms to 2 sec.
   3. Power Consumption: Not to exceed 50 watts for flowtube and transmitter combined.
   4. Operating Temperature: Suitable for operation with process fluid temperature from 0 to 140°F.
   5. Interchangeability: Ratio of flow velocity to voltage reference signals generated identical for all meter sizes to permit interchangeability with transmitter without requiring circuit modifications.

6. Solid state construction.
7. Pulse and analog outputs galvanically isolated from input and earth ground.
8. Automatic zeroing feature making it unnecessary to zero the instrument before or after placing it in operation.
9. Precalibrated span adjustment providing continuous span adjustment over entire range. Range adjustment: Integral pushbuttons continuously adjustable for full-scale settings from 1 to 31 feet per second.
10. Signal Conditioning: Adjustable damping circuit with response times of 1 to 25 seconds minimum.
11. Low Flow Cutoff: Provide automatic low flow cutoff circuitry to stop pulse output and local totalization when flow drops below 0.5 percent ±0.2 percent of the calibrated upper range valve.
12. Enclosure:
    a. Die cast, low-copper aluminum alloy, NEMA 4.
    b. Finish: Epoxy coating.
13. Mounting:
    a. All transmitter and driver electronics shall be remotely mounted from the flow tubes at locations shown on the Drawings.
    b. Provide complete Type 316 stainless steel mounting hardware.
    c. Type of mounting (wall, support frame or pipe stand), as required.
14. Local Indication:
    a. 3-1/2 digit minimum LCD meter with field selectable engineering units; or analog multi-meter with linear 0 to 100 percent scale for flow rate indication. The engineering units shall be as specified in the Instrument List.
    b. 7-digit electromechanical totalizer or 8 digit electronic LCD totalizer with reset and lithium battery backup. Count scaling shall be as specified in the Instrument List. Totalizer shall be integral with transmitter and visible through viewing window, or shall be externally mounted in a separate NEMA 4X enclosure or condulet with viewing window and installed adjacent to the transmitter.
15. Power Requirements: Designed for operation on 120 VAC ± ten percent, 60 Hz, ±3 Hz power supply.
16. Accessories: As recommended by the Manufacturer.
17. Provide shielded cable assemblies of sufficient length to met mounting locations as shown on DRAWINGS for connection between flowtube and transmitter electronics.
    a. Protect magnetic flow meter transmitter to flowtube shield cable from the sun and weather.

D. Construction and Required Features:
1. Flowtube:
    a. Type: Lined metal flowtubes.
    b. Liner Material: PFTE.

2. Tube Material:
   a. Meter tubes 12-inch and smaller: Type 304 stainless steel.
   b. Metering tubes 14-inch and larger: Type 304 stainless steel, .125-inch wall thickness.
3. Pressure Rating: Greater than or equal to test pressure specified in Section 15050, Piping Systems, for appropriate piping system.
4. Electrodes:
   a. Conical or elliptical shaped.
5. Enclosure:
   a. Materials and Rating: Cast low-copper aluminum alloy or fabricated sheet steel, NEMA 6 rated.
   b. Finish: Finish exterior, except for flange faces, with a high build epoxy paint.
   c. End Connections: For up to 24" line size - ANSI Class 150 suitable for mating with pipe specified. For over 24" line size – AWWA Class D Flanges. For Higher Pressures – AWWA Class E & F Flanges
6. Electrical Connections: 1/2 inch minimum to 3/4-inch maximum NPT tapped holes for power conduit fitting and signal conduit fittings.
7. Type 316 stainless steel grounding rings for flowtubes.
8. Type 316 stainless steel grounding straps.

E. Provide one calibrator suitable to calibrate all flow tubes provided.

F. Product and Manufacturer: Provide one of the following:
   1. Endress + Hauser Promag W 400 Series remote version. (City Preferred).
   2. Sitrans FM Mag 5100W with FM Mag 6000 remote transmitter.

INSTRUMENT TYPE L1 - LEVEL TRANSMITTER – ULTRASONIC TYPE

A. Type: Non-contact system using transducer to convert electrical pulses from the transmitter into sonic pulses directed towards the metered surface and receives the reflected sonic pulses and converts them back into electrical pulses for reception by the transmitter. Transmitter shall generate and time the electrical pulses, and count and convert the pulse travel times into an analog output signal linearly proportional to level/flow.

B. System Performance Requirements:
   1. Accuracy: Not less than ± 0.25 percent of full-scale range.
   2. Linearity and Repeatability: Not less than ±1 percent of full scale.
   3. Resolution shall be 0.1 percent of range of 2mm (0.08") whichever is grater.
   4. Minimum Operating Distance from Transducer (Deadband): 12-inches.
   5. Beam Pattern: As Reccommended by the manufacturer.
   6. Transmitter Outputs: Provide each of the following:
      a. 4 to 20 mADC, direct acting and isolated, signal proportional to

level, into 0 to 750 ohms.

b. Minimum of six (6) independently adjustable alarm setpoint, relays outputs rated at five amps, 250 VAC non-inductive.

c. Loss of echo relay, which energizes when measured level falls beyond signal range or signal, is interrupted for any other reason. Relay output shall be rated five amps 250 VAC non-inductive.

7. Environmental Conditions: Suitable for use under the environmental conditions specified in Division 17, Process Control System General Requirements for Process Instrumentation.
8. Power Consumption: 25 watts, maximum.
9. Temperature Compensation: Range – 58 to 302ºF, integral temperature sensor in transducer.

C. Required Features:

1. Transducer:
   a. Encapsulated by a corrosion resistant and submergence resistant material: PVDF.
   b. Class, division, and group as applicable for this project.
   c. Designed for suspended PVC coated galvanized rigid steel conduit mounting or equipped with ANSI 150 pound flanges for flange mounting.
   d. 1-inch external NPT PVC coated galvanized rigid steel conduit connection.
2. Transmitter:
   a. Solid state construction.
   b. Built-in digital filtering for EMI protection and external acoustical noise rejection.
   c. Built-in automatic compensation for variations in temperature, pressure and density of the sonic signal medium.
   d. LCD indicator scaled in engineering units for the range required.
   e. Software adjustable zero and span adjustment over 0 to 100 percent of the calibrated range.
   f. Lost Echo and Power On Lights.
   g. Housed in weatherproof, splash proof and corrosion resistant NEMA 4X enclosure and suitable wall or pipe stand mounting. Provide with a transparent window to permit viewing indicating meter and lights.
   h. Internally mounted diagnostic LED's to allow isolation of faults in terms of major components.
   i. Designed for operation on 120 VAC ±10 percent, 60 Hz power supply.
3. Accessories:
   a. Transducer cables 2-3 copper conductors, twisted with shield and drain wire, the actual length required, for connection between the transducer and transmitter
   b. One Hand held calibrator

D. Product and Manufacturer: Provide the following:
   1. HydroRanger with EchoMax Transducer Model XRS-5 for Class 1, Division 2, EchoMax Transducer Model XPS-15 for Class 1, Division 1 (Wetwells) and Model ST-H for chemical storage tanks, as manufactured by Siemens.

INSTRUMENT TYPE N1 - STROBE LIGHT/HORN

A. General: Strobe light with horn shall be a pulsating, illuminating, multi-tone audible device providing warning in an area where a potential hazard may occur. A strobe light without horn shall provide warning at entrances to aforementioned area.

B. Service: Indoors (wet atmosphere)/Outdoors/Hazardous Area.

C. Required Features:
   1. Power Required: 120 VAC, 60 Hz.
   2. Strobe Light: Minimum 250 candlepower; 360-degree pattern.
   3. Flashing Mechanism: 72 to 75 flashes per minute.
   4. Dome Material of Construction: Polycarbonate.
   5. Color: Amber/Red/Blue.
   6. Base Materials of Construction: Aluminum (NEMA 4X Rated)/Cast Aluminum (NEMA 7 Rated).
   7. Mounting: Wall/Ceiling: Provide appropriate brackets and appurtenances.
   8. Decibel Output: 100 at ten feet minimum with manual volume control.
   9. Provide 12 by 18-inch safety sign with each strobe light.

D. Product and Manufacturer: Provide one of the following:
   1. NEMA 4X Rated: 400 ST/350; as manufactured by Federal Signal.

      c. Diaphragm Seal Housing, Flanges and Bolting (non-process wetted) Materials: Type 316 stainless steel.
      d. Capillary Tubing:
         1) Material: Armored Type 316 stainless steel.
         2) Length: As required to extend from remote seal to transmitter (five feet minimum; 25 feet maximum).
      e. Fill Fluids:
         1) Remote Seal and Capillary: DC 200 silicone oil.
   22. Indicator: Provide integral indicator in engineering units.
   23. Hazardous Area Requirements: Where so required, provide transmitters rated for use in Class I, Group D, Division 1 hazardous areas.
   24. Hand held interface with keyboard and LED display capable of easily configuring and testing the transmitter.

C. Product and Manufacturers: Provide one of the following:
   1. Yokogawa.
   2. Rosemount, Incorporated.
   3. Honeywell.

INSTRUMENT TYPE PS2 - DIFFERENTIAL PRESSURE SWITCH

A. General: The differential pressure switch shall be capable of sensing pressure from two sources and, when their difference reaches a preset value, close or open sets of unpowered contacts capable of passing five amps at 120 VAC minimum.

B. Required Features:
   1. NEMA 4X housing; except in hazardous areas, provide explosion proof (NEMA 7).
   2. Covered (NEMA 4) terminal strip.
   3. Slack diaphragm type.
   4. Switch body and diaphragm shall be capable of sustaining 100 percent pressure reversal throughout its range.
   5. Pressure Connection: 1/8-inch NPT internal thread.
   6. Material: All wetted parts to be metal selected from table in Article 1.6, above, based on process fluid being measured.

C. Assembly: Where specified equipment is shown to be mounted to annular or diaphragm seals, equipment and seal shall be factory assembled, calibrated and furnished as a single unit.

D. Product and Manufacturer: Provide one of the following:
   1. United Electric Controls, Model.
   2. Dwyer, Model.

INSTRUMENT TYPE P3 - PRESSURE GAUGE

A. Bourdon Tube Pressure Element Type, Liquid Filled Gage (for pressure ranges of 15 psi and greater and vacuum ranges to 30-inches Hg):
   1. Performance Requirements:
      a. Accuracy: ±0.5 percent of span (ANSI B40.1 Grade 2A).
   2. Construction Features:
      a. Case:
         1) Solid front design constructed of glass filled polyester.
         2) Color: Black.
      b. Ring: Threaded, glass filled polyester.
      c. Full blowout back.
      d. Window: Glass.
      e. Dial: White with black marking; 270-degree scale.
      f. Material: All wetted parts to be metal selected from table in Article 1.6, above, based on process fluid being measured.

g. Movement: Cam and roller movement, 300 Series stainless steel.
h. Size: 4-1/2-inch.
i. Connection: 1/4-inch male NPT back or bottom, as required.
j. Mounting: Stem, flush panel or wall mounting, as required.
k. Adjustable pointer.
l. Built-in overload and underload movement stops.
m. Pressure Snubber: Sintered Type 316 stainless steel snubber threaded into gage socket or in external stainless steel housing with 1/4-inch NPT male and female connections.

3. Assembly: Where specified equipment is shown to be mounted to annular or diaphragm seals, equipment and seal shall be factory assembled, calibrated and furnished as a single unit.
4. Gauge Filling Liquid: Silicone Oil

B. Product and Manufacturer: Provide one of the following:
1. Helicoid.
2. 3D Instruments, Inc.
3. Ashcroft.
4. Or Equal

INSTRUMENT TYPE P5 - PRESSURE INDICATING TRANSMITTER - CERAMIC FLUSH MOUNTED DIAPHRAGM (FOR SEWAGE LIFT STATIONS)

A. Type: Two-wire, capacitance type, direct mount gage ceramic diaphragm flush mounted pressure indicating transmitter.

B. Required Features and Accessories:
1. Accuracy (includes combined effects of linearity, hysteresis and repeatability): ±0.1 percent of calibrated span.
2. Stability (drift over a six month period): Not more than ±0.1 percent of transmitter's upper range limit.
3. Ambient Temperature Effect: Total Error per 100°F change between the limits of -20°F and +180°F: Not more than ±1.0 percent of the transmitter u upper range limit (maximum span).
4. Hysteresis is less than or equal to .02% of full scale.
5. Supply Voltage Effect: Less than or equal to 0.1% of full scale per 10 volt change
6. Output:
a. Isolated direct acting 4 to 20 mADC, Plus Hart digital signal
b. Digital process variable signal superimposed on 4 to 20 mADC signal without compromising loop integrity.
c. Zero and span adjustments by internal keys or Hart Communicator
d. Damping adjustable 0 to 25 seconds minimum.
7. Solid state electronic components.
8. Positive over range protection of at least 1.25 times the maximum span limit.
9. Calibration Adjustments:

a. Zero: Adjustable in electronics compartment.
b. Span: Course and fine span adjustments in electronics compartment.
c. Process Range - 0 PSI to 200 PSI
    1. The measurement range can be set up from keys/buttons on the pressure transmitter, or HART communicator
    2. Start and end of measurement range can be continuously adjusted within the nominal range.

10. Zero elevation and suppression capability to the extent that the amount of suppression plus calibrated span does not exceed the upper range limits of the sensor.
11. Built-in electrical surge and RFI protection.
12. Electrical Connection ½" – NPT with side cover
13. Supply Voltage: 24 VDC - Tranmitter operations between 11.5 to 36 Volts DC.
15. Process Connection: Threaded ANSI MNPT 1-1/2" 316L flush mount into a saddle tap or weld-a-let fitting.
16. Non-Wetted Parts:
    a. Body: Type 316 stainless steel.
    b. Housing and Cover: Die cast low copper aluminum alloy finished with epoxy paint system; covers shall be threaded and seated on Buna-N O-rings; NEMA 4/6P (IP66/67) rating.
17. Sensor: The ceramic sensor is a dry "no oil fill required" sensor in contact with process fluid wastewater being measured.
18. Software Functionality
    a. Transmitter shall be capable of digital communications over the 4 to 20mA output loop without interruption using the Hart Protocol.
    b. Transmitter shall perform continuous diagnostics, be capable of self-test functions, and be able to give specific diagnostic information such as measurement error, out of range measurement output signal on error
    c. Configuration capabilities shall allow the user the ability to input and store information including range, engineering units, damping, output signal , message descriptor, and tag number.
19. Seal: FPM Viton
20. Hazardous Area Requirements: FM Class I, Division 2, Groups A-D
21. Provide LCD display. Display Units in PSI. Display capable of showing indication of over range or error
22. Bursting Pressure for all ranges: 1,000 PSI
23. Storage temperature -40 to +120 degrees centigrade

C. Product and Manufacturer:
    1. Rosemount 3051CG4A02A1AM5E5S5T1

INSTRUMENT TYPE PE1 - DIAPHRAGM SEAL

A. General: Furnish diaphragm seals for pressure gages, pressure switches and pressure transmitters at locations shown on the Drawings and as specified.

B. Required Features:
   1. Provide fill/bleed screw to permit filling of instrument and diaphragm seal.
   2. Instrument Connection: Coordinate size with attached instrument NPT.
   3. Process Connection: 1/2-inch NPT.
   4. Working Pressure Rating: Equal to or greater than the attached gage or switch operating pressure specified in Section 15050, Piping Systems, whichever is greater.
   5. Filling Fluid:
      a. Silicone.
      b. For Chlorine or Fluoride systems: Halocarbon or Flurolube Oil.
   6. Provide a clean-out ring which holds the diaphragm captive in the upper housing to allow the upper housing assembly to be removed for recalibration or cleaning of the process side housing without the loss of filling liquid or change in calibration.
      a. 1/4-inch NPT flushing connection.

C. Construction Features:
   1. Top Housing:
      a. Type 316 stainless steel.
      b. For Chlorine gas or liquid: Hastelloy C, Monel, or Tantalum.
   2. Material: All wetted parts to be metal selected from table in Article 1.6, above, based on process fluid being measured.

D. Assembly and Calibration:
   1. The complete diaphragm seal assembly, including gage, switch or transmitter, shall be factory assembled, filled and calibrated to the ranges and switch setpoints specified prior to shipment.
   2. System Supplier shall be responsible for assuring that fill volumes and sensitivities of the supplied seals and diaphragms are suitable to provide the required gage, switch or transmitter accuracy over the specified measurement range or at switch setpoints.
   3. Location and orientation of the gages, switches and seal assemblies shall be coordinated with the actual piping and equipment installations so that gages and indicators shall be easily read and accessed for maintenance by plant personnel.
   4. Where field mounting and orientation conflicts arise due to incomplete coordination with field changes in the process piping and equipment installation, assemblies shall be relocated, re-oriented, re-assembled and re-calibrated as directed by ENGINEER.

E. Product and Manufacturer: Provide one of the following:
   1. Ametek/Mansfield & Green (for low pressures).

2. Emerson/Helicoid.
3. Ashcroft.

2.3 SPARE PARTS AND TEST EQUIPMENT

A. Furnish and deliver the spare parts and test equipment as outlined below, all of which shall be identical and interchangeable with similar parts furnished under this Section. Comply with the requirements of Section 01783, Spare Parts and Maintenance Materials.

B. Spare parts shall be packed in containers suitable for long term storage, bearing labels clearly designating the contents and the pieces of equipment for which they are intended.

C. The following shall constitute the minimum spare parts: As recommended by the Manufacturers.

D. The following shall constitute the minimum test and calibration equipment.
1. All tooling required to insert, extract and connect any internal or external connector, including edge connectors.
2. All special calibration equipment required for system calibration.

E. All spare parts shall have been operated and tested in the factory as part of factory testing prior to shipment of the control system.

PART 3 - EXECUTION

3.1. INSTALLATION

A. Provide the services of qualified factory-trained servicemen to assist in the installation of the instrumentation and control system equipment.

B. Install each item in accordance with manufacturer's recommendations and in accordance with the CONTRACT DOCUMENTS. Transmitters and instruments require access for periodic calibration or maintenance. Transmitters and instruments shall be mounted so they are accessible while standing on the floor.

C. All items shall be mounted and anchored using Type 316 stainless steel hardware, unless otherwise noted.

D. All field instruments shall be rigidly secured to walls, stands or brackets, as required, by the manufacturer and as shown on the Drawings. Mounting instruments on handrails will not be allowed.

E. Conform to all applicable provisions of the NEMA and NFPA standards, local, state and federal codes when installing the equipment and interconnecting wiring.

3.2 START-UP, CALIBRATION, AND TESTING AND TRAINING

A. Comply with the requirements of Section 17001, Process Control System General Requirements for Process Instrumentation.

B. Calibration of Instruments:
   a. All instruments are to be field calibrated and witnessed by the ENGINEER through their entire range or with the required setpoints based on the requirements stated in Specification 17053 – Process Control System Instrument Index prior to start-up. Factory calibrated instruments are required to be recalibrated in the field prior to start-up and witnessed by the ENGINEER. Utilized form 17001-B - Calibration Test Data Form as provided in Specification 01331 – Reference Forms to document the field calibration.

C. Primary Sensors/Transducers and Field Instruments:
   a. Provide on-site operation and maintenance training by EQUIPMENT SUPPLIERS and/or the EQUIPMENT MANUFACTURER REPRESENTATIVES prior to placing the equipment in continuous operation, conforming to the requirements of Section 01821, Instruction of Operations and Maintenance Personnel. The services of equipment manufacturer's representatives shall be provided for a minimum of two (2) hours for each type of instrument.

   b. Training shall accomplish the following:
      1) Provide instruction covering procedures for routine, preventive and troubleshooting maintenance and equipment calibration.

+ + END OF SECTION + +

SECTION 17053

PROCESS CONTROL SYSTEM
INSTRUMENT INDEX

PART 1 – GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish, install, calibrate, test, adjust, commission and place into satisfactory operation all primary sensors, field instruments and devices furnished.
   2. Contract Documents illustrate and specify functional and general construction requirements of the sensors and field instruments and devices and do not necessarily show or specify all components, wiring, piping and accessories required to make a completely integrated system. Provide all components, piping, wiring, accessories and labor required for a complete, workable and integrated system.

B. Coordination:
   1. Coordinate the installation of all items specified herein and required to ensure the complete and proper interfacing of all the components and systems.
   2. Comply with the requirements of Section 17001 - Process Control System General Requirements for Process Instrumentation.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

++ END OF SECTION ++

INSTRUMENT INDEX

Tag Number	P&ID	Serial Key #	Service Description	Spec. Inst. Type	Device	Size / Rating	Range	Setpoints	COMMENTS
LIT-1101	I-09	TBD	Wetwell 1 Level	L1	Level Transmitter		0-33 Feet	LSL - 2.5 Feet (from wet well floor)	Wet Well is total 32.5 feet deep
LIT-1102	I-09	TBD	Wetwell 1 Level	L1	Level Transmitter		0-33 Feet	LSH - 12 feet (from wet well floor), Start Lead - 8 feet (from wet well floor), Stop Lead - 4 feet (from wet well floor) Start Lag - 10 feet (from wet well floor), Stop Lag - 6 feet (from wet well floor)	Wet Well is total 32.5 feet deep
PI-101	I-09	N/A	Wastewater Pump No.1 Discharge Pressure	P3	Pressure Guage		0-90 PSI		
PIT-101	I-09	TBD	Wastewater Pump No.1 Discharge Pressure	P5	Pressure Transmitter		0-90 PSI		
PIT\PI-101	I-09	N/A	Wastewater Pump No.1 Discharge Pressure Diaphragm Seal	PE1	Diaphragm Seal				
PI-102	I-09	N/A	Wastewater Pump No.2 Discharge Pressure	P3	Pressure Gauge		0-90 PSI		
PIT-102	I-09	TBD	Wastewater Pump No.2 Discharge Pressure	P5	Pressure Transmitter		0-90 PSI		
PIT\PI-102	I-09	N/A	Wastewater Pump No.2 Discharge Pressure Diaphragm Seal	PE1	Diaphragm Seal				
LIT-1103	I-10	TBD	Wetwell 2 Level	L1	Level Transmitter		0-33 Feet	LSL - 2.5 Feet (from wet well floor)	Wet Well is total 32.5 feet deep
LIT-1104	I-10	TBD	Wetwell 2 Level	L1	Level Transmitter		0-33 Feet	LSH - 12 feet (from wet well floor), Start Lead - 8 feet (from wet well floor), Stop Lead - 4 feet (from wet well floor) Start Lag - 10 feet (from wet well floor), Stop Lag - 6 feet (from wet well floor)	Wet Well is total 32.5 feet deep
PI-103	I-10	N/A	Wastewater Pump No.3 Discharge Pressure	P3	Pressure Gauge		0-90 PSI		
PIT-103	I-10	TBD	Wastewater Pump No.3 Discharge Pressure	P5	Pressure Transmitter		0-90 PSI		
PIT\PI-103	I-10	N/A	Wastewater Pump No.3 Discharge Pressure Diaphragm Seal	PE1	Diaphragm Seal				
PI-104	I-10	N/A	Wastewater Pump No.4 Discharge Pressure	P3	Pressure Gauge		0-90 PSI		
PIT-104	I-10	TBD	Wastewater Pump No.4 Discharge Pressure	P5	Pressure Transmitter		0-90 PSI		
PIT\PI-104	I-10	N/A	Wastewater Pump No.4 Discharge Pressure Diaphragm Seal	PE1	Diaphragm Seal				
FIT-111	I-11	TBD	Force Main No.1 Flow	F1	Flow Transmitter	24"	0 - 11,200 GPM		
FIT-112	I-11	TBD	Force Main No.2 Flow	F1	Flow Transmitter	24"	0 - 11,200 GPM		
PI-1200	I-12	N/A	Biofilter Blower Inlet Pressure	P3	Pressure Gauge		0- 10 PSI		
PI-1200A	I-12	N/A	Biofilter Blower Outlet Pressure	P3	Pressure Gauge		0- 15 PSI		
DPS-1200	I-12	N/A	Biofilter Blower Differential Pressure	PS2	Differential Pressure Switch		0- 15 PSI	DPH - xxx PSI See Comments	To be determined in field. Low should be around 3-4 PSI and high should be around 12-13 PSI.

+ + END OF SECTION + +

SECTION 17226

PROCESS CONTROL SYSTEM I/O LIST

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. The I/O list is comprised of two lists:
      a. As indicated on the P&ID drawings and the herein I/O list.
      b. The other shall be obtained from the existing PLC by the Contractor.

      The resulting comprehensive (all inclusive) I/O list shall then be further developed to include all parameters (similar to the I/O spreadsheet). This I/O list shall be submitted to the ENGINEER for review.

B. The form provided in this section, identifies the person(s) who witnessed all loop testing. The loop testing shall include the field device through to the computer control system. Once the loop is fully tested and complete, each witness will initial the appropriate space on the form.

C. Completed form to be transmitted to the OWNER.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

++ END OF SECTION ++

SCADA PROCESS CONSTROL SYSTEM I/O LIST - COMPUTER CONTROL SYSTEM SPREADSHEET

CCS Programmer	Const. Admin	Contractor	I&C Inspector	P&ID Sheet No.	Device Loop #	Existing Point?	Service Description	Tag Extension	Serialized Key	Physical Address (Rack/Slot)	I/O Type	Communication Protocol	I/O Path				Counts - Low	Counts - High	Eng Units - Low (0%)	Eng Units - High (100%)	Eng Units	Alarm Setpoint	Alarm Priority	Archived Data					Comments
													Communication Line	Node Address	Point Address	Register Address								Archive	HARS Business	HARS Regulatory	Requester / Owner / Application	Archive Duration (<1mo/6mo/1yr/10y)	
				I-09	ZIL-100A	Y	Sluice Gate 100A Closed Status	SLUICE_GATE_100A_CLOSED	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	ZIH-100A	Y	Sluice Gate 100A Opened Status	SLUICE_GATE_100A_OPENED	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	HS-100A	Y	Sluice Gate 100A In Computer	SLUICE_GATE_100A_IN_COMPUTER	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	YS-100A	Y	Sluice Gate 100A Disconnect Closed	SLUICE_GATE_100A_DISC_SW_CLOSED	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	HMS-100A	Y	Sluice Gate 100A Close Command	SLUICE_GATE_100A_CLOSE	TBD	TBD	DO	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	HMS-100A	Y	Sluice Gate 100A Open Command	SLUICE_GATE_100A_OPEN	TBD	TBD	DO	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	ZIL-100B	Y	Sluice Gate 100B Closed Status	SLUICE_GATE_100B_CLOSED	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	ZIH-100B	Y	Sluice Gate 100B Opened Status	SLUICE_GATE_100B_OPENED	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	HS-100B	Y	Sluice Gate 100B In Computer	SLUICE_GATE_100B_IN_COMPUTER	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	YS-100B	Y	Sluice Gate 100B Disconnect Closed	SLUICE_GATE_100B_DISC_SW_CLOSED	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	HMS-100B	Y	Sluice Gate 100B Close Command	SLUICE_GATE_100B_CLOSE	TBD	TBD	DO	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	HMS-100B	Y	Sluice Gate 100B Open Command	SLUICE_GATE_100B_OPEN	TBD	TBD	DO	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	ZIL-105	Y	Sluice Gate 105 Closed Status	SLUICE_GATE_105_CLOSED	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	ZIH-105	Y	Sluice Gate 105 Opened Status	SLUICE_GATE_105_OPENED	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	HS-105	Y	Sluice Gate 105 In Computer	SLUICE_GATE_105_IN_COMPUTER	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	YS-105	Y	Sluice Gate 105 Disconnect Closed	SLUICE_GATE_105_DISC_SW_CLOSED	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	HS-105	Y	Sluice Gate 105 Close Command	SLUICE_GATE_105_CLOSE	TBD	TBD	DO	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	HS-105	Y	Sluice Gate 105 Open Command	SLUICE_GATE_105_OPEN	TBD	TBD	DO	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	HS-101	N	Pump 1 VFD In Auto	PUMP1_VFD_IN_AUTO	TBD	TBD	DI	SOFT		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	MN-101	N	Pump 1 VFD Run Status	PUMP1_VFD_RUNNING	TBD	TBD	DI	SOFT		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	YA-101	N	Pump 1 VFD Fault	PUMP1_VFD_FAULT	TBD	TBD	DI	SOFT		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	YA-101A	N	Pump 1 PEM Module Alarm	PUMP1_PEM_ALARM	TBD	TBD	DI	SOFT		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	YS-101	N	Pump 1 Disconnect Closed	PUMP1_VFD_DISC_SW_CLOSED	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	HS-101B	N	Pump 1 Emergency Stop Active	PUMP1_EMERGENCY_STOP	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	HS-101	N	Pump 1 Start	PUMP1_START	TBD	TBD	DO	SOFT		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	HMS-101	N	Pump 1 Stop	PUMP1_STOP	TBD	TBD	DO	SOFT		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	HMS-101C	N	Pump 1 Reset	PUMP1_RESET	TBD	TBD	DO	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	SI-100	N	Pump 1 Speed Status	PUMP1_VFD_SPEED	TBD	TBD	AI	SOFT		TBD	TBD	TBD	0	TBD	0	100	%	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	SC-100	N	Pump 1 Speed Control	PUMP1_VFD_SPEED_CONTROL	TBD	TBD	AO	SOFT		TBD	TBD	TBD	0	TBD	0	100	%	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	PIT-101	N	Pump 1 Discharge Pressure	PUMP1_DISCH_PRESS	TBD	TBD	AI	MOD		TBD	TBD	TBD	0	TBD	0	XXX	PSI	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	YIH-101	N	Pump 1 Discharge Valve Opened Status	PUMP1_DISCH_VALVE_OPENED	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	YIL-101	N	Pump 1 Discharge Valve Closed Status	PUMP1_DISCH_VALVE_CLOSED	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	HMS-101	N	Pump 1 Discharge Valve Open Command	PUMP1_DISCH_VALVE_OPEN	TBD	TBD	DO	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	HMS-101A	N	Pump 1 Discharge Valve Close Command	PUMP1_DISCH_VALVE_CLOSE	TBD	TBD	DO	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	HS-101	N	Pump 1 Discharge Valve In Remote	PUMP1_DISCH_VALVE_IN_REMOTE	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	HS-102	N	Pump 2 VFD In Auto	PUMP2_VFD_IN_AUTO	TBD	TBD	DI	SOFT		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	MN-102	N	Pump 2 VFD Run Status	PUMP2_VFD_RUNNING	TBD	TBD	DI	SOFT		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	YA-102	N	Pump 2 VFD Fault	PUMP2_VFD_FAULT	TBD	TBD	DI	SOFT		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	YA-102A	N	Pump 2 PEM Module Alarm	PUMP2_PEM_ALARM	TBD	TBD	DI	SOFT		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	YS-102	N	Pump 2 Disconnect Closed	PUMP2_VFD_DISC_SW_CLOSED	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	HS-102B	N	Pump 2 Emergency Stop Active	PUMP2_EMERGENCY_STOP	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	HMS-102	N	Pump 2 Start	PUMP2_START	TBD	TBD	DO	SOFT		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	HMS-102	N	Pump 2 Stop	PUMP2_STOP	TBD	TBD	DO	SOFT		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	HS-102C	N	Pump 2 Reset	PUMP2_RESET	TBD	TBD	DO	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	SI-100	N	Pump 2 Speed Status	PUMP2_VFD_SPEED	TBD	TBD	AI	SOFT		TBD	TBD	TBD	0	TBD	0	100	%	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	SC-100	N	Pump 2 Speed Control	PUMP2_VFD_SPEED_CONTROL	TBD	TBD	AO	SOFT		TBD	TBD	TBD	0	TBD	0	100	%	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	PIT-102	N	Pump 2 Discharge Pressure	PUMP2_DISCH_PRESS	TBD	TBD	AI	MOD		TBD	TBD	TBD	0	TBD	0	XXX	PSI	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	YIH-102	N	Pump 2 Discharge Valve Opened Status	PUMP2_DISCH_VALVE_OPENED	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	YIL-102	N	Pump 2 Discharge Valve Closed Status	PUMP2_DISCH_VALVE_CLOSED	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	HMS-102	N	Pump 2 Discharge Valve Open Command	PUMP2_DISCH_VALVE_OPEN	TBD	TBD	DO	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	HMS-102A	N	Pump 2 Discharge Valve Close Command	PUMP2_DISCH_VALVE_CLOSE	TBD	TBD	DO	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-09	HS-102	N	Pump 2 Discharge Valve In Remote	PUMP2_DISCH_VALVE_IN_REMOTE	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	

SCADA PROCESS CONSTROL SYSTEM I/O LIST - COMPUTER CONTROL SYSTEM SPREADSHEET

			I-09	LIT-1101	N	Wetwell 1 Level Meter 1	WETWELL1_LEVEL_METER1	TBD	TBD	AI	MOD		TBD	TBD	TBD	0	TBD	0	XXX	Feet	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-09	LIT-1102	N	Wetwell 1 Level Meter 2	WETWELL1_LEVEL_METER2	TBD	TBD	AI	MOD		TBD	TBD	TBD	0	TBD	0	XXX	Feet	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-09	HS-105A	N	Wetwell High Level Reset	WETWELL_HIGH_LEVEL_RESET	TBD	TBD	DO	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-09	YI-101A	Y	Wetwell 1 Process Normal	WW1_PROCESS_NORMAL	TBD	TBD	DO	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-09	YI-101C	Y	Wetwell 1 Low Flow or High Gas Concentration	WW1_LOW_FLOW_HIGH_GAS_CONC	TBD	TBD	DO	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-09	LSH-101/102	N	Wetwell 1/2 High Level	WETWELL_HILEVEL	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-09	LSLL-101	N	Wetwell 1 Low Level	WETWELL1_LOLEVEL	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-09	HS-1101	N	Backup Level Mode In Local	BACKUP_LEVEL_MODE_LOCAL	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-09	HS-1101	N	Backup Level Mode In RTU	BACKUP_LEVEL_MODE_RTU	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-09	TIT-100	Y	Wetwell 1 Water Temp Out	WETWELL1_WATER_TEMP_OUT	TBD	TBD	AI	MOD		TBD	TBD	TBD	0	TBD	0	XXX	deg F	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-10	HS-103	N	Pump 3 VFD In Auto	PUMP3_VFD_IN_AUTO	TBD	TBD	DI	SOFT		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-10	MN-103	N	Pump 3 VFD Run Status	PUMP3_VFD_RUNNING	TBD	TBD	DI	SOFT		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-10	YA-103	N	Pump 3 VFD Fault	PUMP3_VFD_FAULT	TBD	TBD	DI	SOFT		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-10	YA-103A	N	Pump 3 PEM Module Alarm	PUMP3_PEM_ALARM	TBD	TBD	DI	SOFT		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-10	YS-103	N	Pump 3 Disconnect Closed	PUMP3_VFD_DISC_SW_CLOSED	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-10	HS-103B	N	Pump 3 Emergency Stop Active	PUMP3_EMERGENCY_STOP	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-10	HS-103	N	Pump 3 Start	PUMP3_START	TBD	TBD	DO	SOFT		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-10	HMS-103	N	Pump 3 Stop	PUMP3_STOP	TBD	TBD	DO	SOFT		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-10	HMS-103C	N	Pump 3 Reset	PUMP3_RESET	TBD	TBD	DO	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-10	SI-100	N	Pump 3 Speed Status	PUMP3_VFD_SPEED	TBD	TBD	AI	SOFT		TBD	TBD	TBD	0	TBD	0	100	%	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-10	SC-100	N	Pump 3 Speed Control	PUMP3_VFD_SPEED_CONTROL	TBD	TBD	AO	SOFT		TBD	TBD	TBD	0	TBD	0	100	%	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-10	PIT-103	N	Pump 3 Discharge Pressure	PUMP3_DISCH_PRESS	TBD	TBD	AI	MOD		TBD	TBD	TBD	0	TBD	0	XXX	PSI	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-10	YIH-103	N	Pump 3 Discharge Valve Opened Status	PUMP3_DISCH_VALVE_OPENED	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-10	YIL-103	N	Pump 3 Discharge Valve Closed Status	PUMP3_DISCH_VALVE_CLOSED	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-10	HMS-103	N	Pump 3 Discharge Valve Open Command	PUMP3_DISCH_VALVE_OPEN	TBD	TBD	DO	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-10	HMS-103A	N	Pump 3 Discharge Valve Close Command	PUMP3_DISCH_VALVE_CLOSE	TBD	TBD	DO	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-10	HS-103	N	Pump 3 Discharge Valve In Remote	PUMP3_DISCH_VALVE_IN_REMOTE	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-10	HS-104	N	Pump 4 VFD In Auto	PUMP4_VFD_IN_AUTO	TBD	TBD	DI	SOFT		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-10	MN-104	N	Pump 4 VFD Run Status	PUMP4_VFD_RUNNING	TBD	TBD	DI	SOFT		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-10	YA-104	N	Pump 4 VFD Fault	PUMP4_VFD_FAULT	TBD	TBD	DI	SOFT		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-10	YA-104A	N	Pump 4 PEM Module Alarm	PUMP4_PEM_ALARM	TBD	TBD	DI	SOFT		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-10	YS-104	N	Pump 4 Disconnect Closed	PUMP4_VFD_DISC_SW_CLOSED	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-10	HS-104B	N	Pump 4 Emergency Stop Active	PUMP4_EMERGENCY_STOP	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-10	HMS-104	N	Pump 4 Start	PUMP4_START	TBD	TBD	DO	SOFT		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-10	HMS-104	N	Pump 4 Stop	PUMP4_STOP	TBD	TBD	DO	SOFT		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-10	HS-104C	N	Pump 4 Reset	PUMP4_RESET	TBD	TBD	DO	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-10	SI-100	N	Pump 4 Speed Status	PUMP4_VFD_SPEED	TBD	TBD	AI	SOFT		TBD	TBD	TBD	0	TBD	0	100	%	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-10	SC-100	N	Pump 4 Speed Control	PUMP4_VFD_SPEED_CONTROL	TBD	TBD	AO	SOFT		TBD	TBD	TBD	0	TBD	0	100	%	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-10	PIT-104	N	Pump 4 Discharge Pressure	PUMP4_DISCH_PRESS	TBD	TBD	AI	MOD		TBD	TBD	TBD	0	TBD	0	XXX	PSI	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-10	YIH-104	N	Pump 4 Discharge Valve Opened Status	PUMP4_DISCH_VALVE_OPENED	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-10	YIL-104	N	Pump 4 Discharge Valve Closed Status	PUMP4_DISCH_VALVE_CLOSED	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-10	HMS-104	N	Pump 4 Discharge Valve Open Command	PUMP4_DISCH_VALVE_OPEN	TBD	TBD	DO	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-10	HMS-104A	N	Pump 4 Discharge Valve Close Command	PUMP4_DISCH_VALVE_CLOSE	TBD	TBD	DO	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-10	HS-104	N	Pump 4 Discharge Valve In Remote	PUMP4_DISCH_VALVE_IN_REMOTE	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-10	LIT-1103	N	Wetwell 2 Level Meter 1	WETWELL2_LEVEL_METER1	TBD	TBD	AI	MOD		TBD	TBD	TBD	0	TBD	0	XXX	Feet	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-10	LIT-1104	N	Wetwell 2 Level Meter 2	WETWELL2_LEVEL_METER2	TBD	TBD	AI	MOD		TBD	TBD	TBD	0	TBD	0	XXX	Feet	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-10	YI-102A	Y	Wet Well 2 Process Normal	WW2_PROCESS_NORMAL	TBD	TBD	DO	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-10	YI-102C	Y	Wet Well 2 Low Flow or High Gas Concentration	WW2_LOW_FLOW_HIGH_GAS_CONC	TBD	TBD	DO	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-10	LSLL-103	N	Wetwell 2 Low Level	WETWELL2_LOLEVEL	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-11	FIT-111	N	Force Main 1 Flowrate	FORCE_MAIN1_FLOWRATE_OUT	TBD	TBD	AI	MOD		TBD	TBD	TBD	0	TBD	0	XXX	GPM	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-11	FIT-112	N	Force Main 2 Flowrate	FORCE_MAIN2_FLOWRATE_OUT	TBD	TBD	AI	MOD		TBD	TBD	TBD	0	TBD	0	XXX	GPM	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-11	FIT-111	N	Force Main 1 Flowrate Pulse	FORCE_MAIN1_FLOW_TOTAL	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-11	FIT-112	N	Force Main 2 Flowrate Pulse	FORCE_MAIN2_FLOW_TOTAL	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-12	MN-1200	N	Biofilter Blower Run Status	BIOFILTER_BLOWER_RUNNING	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-12	TSH-1200	N	Biofilter Blower Hi Temp	BIOFILTER_BLOWER_HI_TEMP	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-13	LSHH-101	N	Wetwell 1 High Level	WETWELL1_HILEVEL	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-13	LSHH-103	N	Wetwell 2 High Level	WETWELL2_HILEVEL	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-13	YA-01	N	PLC Failure	PLC_FAILURE	TBD	TBD	DO	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-13	YA-03	N	Generator Common Alarm	COMMON_GEN_ALARM	TBD	TBD	DO	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-13	YA-02	N	UPS Failure	UPS_FAILURE	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-13	YA-101	N	Lift Pump No. 1 Common Fault	COMMON_PUMP1_ALARM	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-13	YA-102	N	Lift Pump No. 2 Common Fault	COMMON_PUMP2_ALARM	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
			I-13	YA-103	N	Lift Pump No. 3 Common Fault	COMMON_PUMP3_ALARM	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	

SCADA PROCESS CONSTROL SYSTEM I/O LIST - COMPUTER CONTROL SYSTEM SPREADSHEET

				I-13	YA-104	N	Lift Pump No. 4 Common Fault	COMMON_PUMP4_ALARM	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-13	YA-04	N	Building High Temp	BUILDING_HIGH_TEMP	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-13	YA-05	N	Security Alarm	SECURITY_ALARM	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-13	YA-1200	N	Biofilter Blower Overload	BIOFILTER_BLOWER_OVERLOAD	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-13	MN-100	N	Generator Running	GENERATOR_RUNNING	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
				I-13	PSL-100	N	Air Receiver Low Pressure	AIR_REC_LOW_PRESS	TBD	TBD	DI	MOD		TBD	TBD	TBD	0	1	n/a	n/a	n/a	TBD	TBD	TBD	TBD	TBD	TBD	TBD	

DIGITAL INPUTS	69
DIGITAL OUTPUTS	33
ANALOG INPUTS	15
ANALOG OUTPUTS	4
TOTAL	121

SECTION 17260

CONTROL PANELS

PART 1 GENERAL

1.1 SCOPE

A. Contract Documents illustrate and specify functional and general construction requirements of the panel components and do not necessarily show or specify all components, wiring, and accessories required for a completely integrated system.

B. Provide all labor, materials, equipment, documentation including drawings and incidentals as shown on the Drawings, specified and required to design, furnish, install, calibrate, test, start-up, program, configure, commission and place into satisfactory operation all panels, intermediate termination panels and/or enclosures including panel components and instruments.

C. Conform the design and construction of panels to the specifications herein.

1.2 COORDINATION

A. Coordinate the installation of all items specified herein and required to ensure the complete and proper interfacing of all the components and systems.

B. All control loops to function as described in Section 17051, Computer Control System Process Control Descriptions and depicted on the CONTRACT DRAWINGS.

1.3 DEFINITIONS

A. **Intermediate Termination Panel (ITP)**: An Intermediate Termination Panel is any junction box that has terminals to terminate wires and no electrical or electronic powered devices. Exceptions are to be approved by the City of Phoenix (COP). These panels act as interim termination points for field wiring to be connected to the control systems equipment. Please note that junction boxes and pull boxes are different. ITP's are sometimes referred to as junction boxes. However, pull boxes are not allowed to have any wire splicing devices, including terminal blocks.

B. **Local Control Panel (LCP)**: A Local Control Panel is an industrial piece of equipment that contains electrical or electronic devices, in addition to wire terminals. Typically, it is a local panel connected to a specific piece of equipment to provide control and/or monitoring of that equipment. A local control panel contains voltages of 120VAC or below. Exceptions are to be approved by COP.

C. **Motor Control Panel (MCP)**: An Motor Control Panel is an industrial piece of equipment that houses components for the power distribution and starting of motors. The components may include motor starters and variable frequency drives.

1.4 QUALITY ASSURANCE

A. Reference Standards: Construction of panels and the installation and interconnection of all equipment and devices mounted within also comply with applicable provisions of the following, except where otherwise shown or specified.
   1. National Fire Protection Association 79
   2. National Electrical Code (NEC) current adoption.
   3. National Electrical Manufacturer's Association Standards (NEMA)
   4. American Society for Testing and Materials (ASTM)
   5. Operational Safety and Health Administration (OSHA) Regulations
   6. State and local code requirements
   7. Where any conflict arises between codes or standards, the more stringent requirement applies.
   8. All panel devices shall bear the label of the Underwriters' Laboratory (UL), Inc. or be UL Recognized. Some products certified by UL are components that are intended to be used in the manufacture of a complete listed product. These components cannot bear the UL symbol, but may use a special Recognized Component Mark.
      a. The UL/UR listed number shall be documented on the Bill of Materials on the drawings.
   9. The assembled LCP's and MCP's are to be conformed to meet UL 508A requirements and labeling.

B. Panel to be designed, schematics drawn and assembled by the manufacturer. Utilize one of the following Panel Manufacturers:
   1. RDC Electrical Corporation – (480) 874-1175
   2. Felix – (520) 374-3990

1.5 SUBMITTALS

A. General:
   1. Reference Section 01330 Submittals.
   2. Panels shall be furnished in accordance with the requirements as shown on the Drawings, and as specified in Division 16, Section 16050 and Division 17000, Sections 17001, 17051, 17052, 17053, 17226 and 17260.
   3. Generate drawing package utilizing AutoCAD versions 2004 through 2008. If utilizing a newer AutoCAD version, submit files saved at version 2008.
   4. Submit legible hard copies of the panel drawing package printed on 11" x 17" sheets and soft copies in both .dwg and .pdf format.
   5. Submit manufacturer's technical data sheets and product literature for the panel and all components utilized. Cleary identify exact equipment and material that is being supplied on the manufacturer's data sheets.

6. Submit a sample nameplate with the submittal.
7. Identify general location of all conduit entry points on the Front Elevation drawing of the documentation package.
8. Submit calculations and recommended cooling and heating load requirements. Utilize the nVent Hoffman Cooling Selection tool at: https://coolingtool.nvent.com/index.html
9. Submit location and tube routing details for air conditioner drain line. Coordinate drain location with ENGINEER.

1.6 O&M Manuals

A. Comply with the requirements of Section 01781, Operations and Maintenance Data.
B. Provide an electronic copy of the panel drawing package on a separate CD. Panel Drawings are to be provided electronically in AutoCAD version 2004 through 2008. If utilizing a newer AutoCAD version, submit files saved at version 2008.

1.7 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Comply with the requirements of Section 01651, Transportation and Handling of Materials and Equipment.
B. Comply with the requirements of 01661, Storage of Materials and Equipment.
C. Provide a laminated hard copy of the panel drawings, size 11" x 17", inside the panel upon delivery or project completion. If redline drawings are utilized, replace with approved laminated copies.

PART 2 - PRODUCTS

2.1 PANEL ENCLOSURES

A. General:
   1. Conform panels and enclosures to the NEMA requirements as stated in Specification 16050 – General Requirements.
   2. All outdoor panels shall be provided with sunshade structures or solar shields. Sunshade structures or solar shields shall be constructed as shown on CONTRACT DRAWINGS.
   3. Sizes shown on contract drawings are estimates. Furnish panels and enclosures sized to house all equipment, instruments, front panel mounted devices, power supplies, power distribution panels, wiring and other components installed within.
   4. Size the panel to provide 10% spare free space capacity.
   5. Use stainless steel fasteners throughout.
   6. Provide interior mounting panels and shelves constructed of minimum 12 gage steel.
   7. Provide 12"x12" print pocket in panels with a 24" or larger door. Mount on inside door where no door mounted devices are located. If there is not enough room for a 12"x12" print pocket, provide a sized pocket to fit available room.

8. Provide enclosure mounting supports as required for floor, frame, or wall mounting. Indoor wall mount panels utilizing stainless steel unistrut. Outdoor wall mount panels utilizing PVC coated unistrut. PVC coated exceptions may be approved by COP for non-corrosive outdoor installs.

B. Construction Features:
   1. General Construction Features - Provide the following convenience accessories inside of each panel.
      a. One or more 120 VAC light fixtures with a minimum 40 watt lamp or LEDs with a snap switch for on/off control.
      b. Provide grounding studs or lugs for metal panels and doors.
      c. Provide all electrical components and devices, support hardware, fasteners, and interconnecting wiring required to make the panels and/or enclosures complete and operational.
      d. Provide oil resistant gasket completely around each door or opening.
      e. For panels located in the field or outdoors that have door mounted devices which do not meet the NEMA rating for the area, provide a window kit that includes a hinged door with a clear plastic window and an oil resistant gasket to encompass all non-NEMA rated panel instruments for this area.
      f. Provide full height doors.
      g. Provide panels with no extra holes or knockouts unless shown on CONTRACT DRAWINGS.

C. Environment
   1. General:
      a. Provide an air conditioner, heat exchanger or ventilation fan when required, based on the submitted calculations for cooling and/or heating load requirements.
      b. Provide a heater for all panels located outdoors to maintain a minimum temperature of 68°F.
      c. Provide a separate supplementary protector for the cooling or heating equipment.
      d. Provide thermostats to automatically control heating and cooling requirements.
      e. Provide a high temperature switch, for alarm purposes, in all panels that require air conditioners, heat exchangers or ventilation fans. The contact shall be wired to alarm to the Computer Control System.
         1) Products and Manufacturers:
            a) Hoffman ATEMNC
            b) Or approved equal
   2. Air Conditioner:
      a. Coordinate utilization of air conditioners with the ENGINEER.
      b. Provide an automatically controlled closed loop air conditioner with filtered and adjustable air louvers to maintain temperature inside each enclosure below the maximum operating temperature rating of the lowest rated component.
      c. Condensate Coltrols:
         1) For outdoor installations, provide a condensation drain line for each air conditioner.
         2) For indoor installations, provide an active condensate evaporation system.
      d. Coordinate space requirements for maintenance.

e. Provide NEMA 4X for outdoor locations.
f. Coat heating and cooling elements on ambient and enclosure sides including coils that are in contact with Plant's ambient environment with Heresite, or equal, for protection from hydrogen sulfide corrosion with hydrogen sulfide levels up to seven ppm.
   1) Coordinate application of coating with the ENGINEER.
g. Provide integral heater to maintain internal temperatures above 40°F.
h. Product and Manufacturer:
   1) Hoffman (McClean) G or N Series, Model Spectra Cool

3. Heat Exchanger:
   a. Coordinate utilization of heat exchangers with the ENGINEER.
   b. Provide an automatically controlled heat exchanger to maintain temperature inside each enclosure below the maximum operating temperature rating of the lowest rated component.
   c. Coordinate space requirements for maintenance.
   d. Products and Manufacturers:
      1) Hoffman
4. Ventilation Fan:
   a. Coordinate utilization of ventilation fans with the ENGINEER.
   b. Provide automatically controlled ventilation fans with filter to maintain temperature of indoor enclosures below the maximum operating temperature of the lowest rated component.
   c. Products and Manufacturers:
      1) Hoffman
      2) Or approved equal
5. Heater:
   a. If panel is not equipped with an air conditioner, provide adequately sized automatically controlled 120 VAC heater to maintain temperature inside each enclosure above 40°F to a maximum of 80°F when the outside temperature is 0°F through 40°F.
   b. Maintain a minimum four inch clearance or minimum clearance recommendations from the manufacturers from any device.
   c. Product and Manufacturer:
      1) Hoffman
      2) Or approved equal

D. Identification:
1. Provide laminated plastic nameplates with a white background and black lettering for identification of panels and components.
2. Construct nameplates with 1/16" plastic and with beveled edges.
3. Nameplate Mounting
   a. Indoor panels: Mount nameplates to the panel utilizing glue.
   b. Outdoor panels: Mount nameplates to the panel utilizing glue and with two self-sealing #4-40, round head, stainless steel screws.
   c. Glue Product and Manufacturer
      1) 3M – Nitrile High Performance Rubber & Gasket Adhesive – Part # EC-847

2) Or approved equal

4. Provide nameplates according to Table 2.1.C.5 and Section 3.1.B:

Nameplate Specifications			
Type	Size	Font	Font Size
Manufacturer Nameplate	*1½" x 6"	Arial	1/8"
Panel Nameplate	*2" x 7"	Arial	1/2"
Device Nameplate	*1½"x 2½"	Arial	3/16"

Table 2.1.C.5 Nameplate Specifications

*** This is a minimum height size requirement. Size nameplates large enough to display the information required to clearly identify the panel.**

2.2 PANEL DEVICES:

A. General:
   1. Provide DIN rail mounted devices where practical.
   2. All devices mounted on the exterior of the panel shall match the NEMA rating of the panel.

B. Internal Component Labeling:
   1. Provide a device label for devices mounted inside the panel that conforms to the criteria below:
      a. Instruments: Provide label with the instrument loop number as shown on the CONTRACT DRAWINGS. Place label below the instrument on the backplane.
      b. Supplementary Protector: Label each supplementary protector with CB and the number assigned in the supplementary protector schedule. Place label on the backplane.
      c. Fuses: Label each fuse with FU and the number assigned in the fuse schedule. Place a label on the backplane that includes the fuse number and the fuse size.
      d. Control Relays: Label each relay with CR and the number assigned in the panel drawings. Place label below the relay on the backplane.
      e. Terminal Strips: Label each terminal strip with the terminal strip type. (ex. TB1, TB2, ATB). Place label above the terminal block or at first terminal on the backplane.
      f. Door Mounted Devices: Provide a label on the interior of the front panel door for every panel device. The label should contain the same information as shown on the front panel nameplate. Place the label below the device.

g. Wireway Covers: Label wireways with the voltage that is being routed through it. For example; "24 VDC" for DC voltage or "120VAC" for AC voltage. Place label on wireway cover. Coordinate label size to fit on wireway cover.
h. Identify internal components with permanent adhesive plastic labels.
   1) Product and Manufacturer:
      a) Brady USA Inc.
      b) Or approved equal
   2) Provide device label size and fonts per Table 2.2.B.1:

Device	Label Size	Font Size	# Points	Brady Part #
(Wireways) 24VDC	1"x 4"	Arial	48 Points	PTL-42-422
(Wireways) 120VAC	1"x 4"	Arial	48 Points	PTL-42-422
Misc. Device Labels	1"x 1"	Arial	16 Points	PTL-19-423
Panel Door Devices	1" x 1.5"	Arial	8 Points	PTL-31-423

Table 2.2.B.1 Panel Interior Device Label

C. DIN Rail
   1. General: DIN rail is the metal rail used to mount various electrical components in a panel
   2. Mount all internal components on DIN Rail
   3. DIN Rail for terminal blocks shall be raised DIN rail to match the height of the wireways.
   4. Product and Manufacturer, Provide one of the following:
      a. Phoenix Contact
      b. Or approved equal

D. Control Circuit – Supplementary Protectors:
   1. Provide single pole supplementary circuit protectors with the following features, 120 Volt AC, DIN rail mounted and UL 1077 listed with auxiliary contacts.
   2. Provide end caps, marking strips, insulated side jumpers and other accessories.
   3. Product and Manufacturer, Provide one of the following models where "xx" is the appropriate rating.
      a. Phoenix Contact, TMC 1-M1-xxA
      b. Allen-Bradley, 1492-SP1Bxxx
      c. Idec, NC1V-XXXXX-XXAA

E. Air Conditioner or Heater Supplementary Protectors:
   1. Provide supplementary protectors with the following features, 120 Volt AC, DIN rail mounted and UL 489 listed with auxiliary contacts.
   2. Product and Manufacturer, Provide one of the following:

a. Allen-Bradley, Bulletin 1489
b. Or approved equal

F. Control Relays:
1. Type: General purpose, plug-in type rated for continuous duty.
2. Construction Features:
a. Coil Voltages: 120 VAC
b. Contacts:
1) Silver cadmium oxide rated not less than ten amperes resistive at 120 VAC or 28 VDC continuous.
2) For switching low energy circuits (less than 200 ma) fine silver, gold flashed contacts rated not less than three amperes resistive at 120 VAC or 28 VDC continuous shall be provided.
3) Number of contacts:
a) Minimum: Two double pole/double throw contact sets
b) Maximum: Four double pole/double throw contact sets.
c. Relays shall have a clear plastic dust cover.
d. Socket type to be blade.
e. Remotes and Lift Stations shall have LED indicator; all other relays are not required to have LED indicators.
3. Product and Manufacturer: Provide one of the following:
a. Square D Company, Type R and/or Type K.
b. IDEC, Type RH and/or Type RY.
c. Potter & Brumfield.
d. Or approved equal.

G. Time Delay Relay:
1. Type: Dial adjustable, plug-in type time delay relay providing delay-on-make, delay-on-break one shots or interval operation.
2. Construction Features:
a. MOS digital circuit with transformer coupled power.
b. Switch selectable ranges
c. Minimum Setting: Three percent of range; except 50 ms for one second range.
d. Contacts:
1) Type: DPDT.
2) Rating: Seven amps resistive at 120 VAC, seven amps at 24 VDC.
e. Housing:
1) Plug-in design with dust and moisture resistant molded plastic case.
f. Power Input: 120 VAC
3. Product and Manufacturer: Provide one of the following:
a. Automatic Timing and Controls Company.
b. IDEC.
c. Or approved equal

H. Selector Switches, Pushbuttons and Indicating Lights:

1. General:
   a. Selector switches, pushbuttons and indicating lights shall be supplied by one manufacturer and be of the same series or model type.
   b. Type: Heavy duty, oil tight
   c. Mounting: Flush mounted on panel front, unless otherwise noted.
   d. NEMA rated to match panel in which mounted.
2. Selector Switches:
   a. Type: Provide selector switches with number of positions as required to perform intended functions as shown on the Drawings and specified.
   b. Contacts:
      1) Provide number and arrangement of contacts as required to perform intended functions specified, but not less than one single pole, double throw contact.
      2) Type: Double break, silver contacts with movable contact blade providing scrubbing action.
      3) Rating: Compatible with AC or DC current with devices simultaneously operated by the switch contacts, but not less than ten amperes resistive at 120 volts AC or DC continuous.
   c. Switch Operator: Standard black knob.
3. Pushbuttons (Standard or Illuminated):
   a. Momentary Type: Provide momentary, booted type pushbuttons as required to perform intended functions specified and shown on the Drawings. Boot color to be red for stop buttons and black for other functions.
   b. Maintained Type: Provide maintained, push/pull, "Mushroom" type, red in color, to perform intended functions as specified, and as shown on the drawings.
      1). Emergency Stop button shall be red and the base of the button shall be yellow.
   c. Contacts: Comply with the requirements specified for selector switches.
4. Indicating Lights:
   a. Type: Compact, integral non-transformer type.
   b. Lamps: 120 VAC, long life (20,000 hours minimum).
   c. Common, push-to-test circuitry shall be provided for each panel to simulta-neously test all indicating lights on the panel using a single pushbutton.
   d. Button and Lens Colors:
      1) Red for indication of open, on, or running.
      2) Green for indication of closed, off (ready), or stopped.
      3) Amber for indication of equipment malfunction, process trouble or alarms.
      4) White for indication of electrical control power on.
5. Rotary Cam Switches:
   a. Provide rotary cam switches with number of positions and poles as required performing the signal switching function specified and shown on the Drawings.
   b. Contacts:
      1) Gold-flashed contacts housed in mechanical contact blocks with number

and arrangement of contacts as required performing intended function.
2) Contact Rating: Compatible with AC or DC through-put current of signals and devices simultaneously operated by the switch contacts, but not less than 20 amperes at 600 VAC or 250 VDC continuous.

c. Switch Operator: Standard black knob.

6. Product and Manufacturer: Provide one of the following:
   a. Square D.
   b. General Electric.
   c. Allen-Bradley Co.
   d. Or approved equal

I. Potentiometer:
1. Type: Industrial potentiometer operator, direct acting, 3/4 to full turn; and standard 3-wire potentiometer.
2. Required Features:
   a. NEMA rated to match panel in which mounted.
   b. Resistance Range: 0 to 10,000 Ohms.
   c. Resistance Element: Wire wound or conductive plastic.
   d. Power Rating: Two watts.
   e. Mounting: Flush mounted on panel front, unless otherwise noted.
   f. Provide legend plate for indication of position (0 to 100 percent).
3. Product and Manufacturer: Provide one of the following:
   a. Square D.
   b. General Electric.
   c. Allen-Bradley Co.

J. Power Supplies:
1. General
   a. Panel power supply source, type, voltage, number of circuits and circuit ratings shall be as shown on the Contract Drawings.
   b. Panels shall be provided with an internal 120 VAC with number of circuits and separate supplementary protectors sized as required to distribute power to the panel components.
2. Power Supplies:
   a. General:
      1) Single unit and multiple unit power supplies, located in panels, as required.
      2) Single Unit Required Features:
         a) Solid state circuitry
         b) Surface mounting
         c) Input Power: 120 VAC, ± 10 percent, 60 Hz.
         d) Output Power: 24 VDC or as required.
         e) Line/Load Regulation: 0.05 percent.
         f) Ripple: 0.25 mv RMS.
         g) Overload Protection: Internal preset or fused.
      3) Product and Manufacturer: Provide one of the following:
         a) Acopian Corporation.
         b) Power One.

c) Lambda
d) Puls

4) If redundant power supplies are required: Provide one of the following:
a) Lambda DPL-PU/E
b) Phoenix Contact Quint-Diode/40
c) Puls
d) Or approved Equal

K. Wire:

1. General
a. Provide internal wiring of Type MTW stranded copper wire with thermo-plastic insulation with no nylon jacket rated for 600 V at 90°C for single conductors.
b. No utilization of Type THHN for panel wiring.
c. For DC panel signal wiring, use #16 AWG shielded minimum.
d. For AC power wiring, use #14 AWG minimum. For AC signal and control wiring, use #16 AWG minimum. For wiring carrying more than 15 amps, use sizes required by NEC and NFPA 79 Standards.
e. Identify wires at each end using heat shrink labels with permanent number codes using a Brady LS2000 Labeling System, or approved equal.
f. Panels conform to the wire color code as shown in Table 2.2.K.1.f Wire Color Code and NFPD 79 Standards.

2. Product and Manufacturer: Provide one of the following:
a. Carol
b. Belden
c. Anixter

WIRE COLOR CODE TABLE (Inside Panels)			
TYPE	FUNCTION	INSULATION COLOR	WIRE SIZE
AC POWER - HOT	120VAC	**BLACK	#14
AC POWER - NEUTRAL	120VAC	WHITE	#14
AC GROUND	120VAC	GREEN	#14
AC CONTROL	120VAC	**RED	#16
ISOLATED DC GROUND	GROUND	GREEN W/YELLOW	#16
DC POWER	SOURCE	BLUE	#16
DC POWER	COMMON	WHITE /BLUE	#16
CONTROL	FOREIGN VOLTAGES	ORANGE	#16
LOW VOLTAGE AC	24 VAC SOURCE	BROWN	#16

LOW VOLTAGE AC	24 VAC COMMON	BROWN W/WHITE	#16
*AC POWER	480 VAC PHASE A	BROWN	Size to FLA
*AC POWER	480 VAC PHASE B	ORANGE	Size to FLA
*AC POWER	480 VAC PHASE C	YELLOW	Size to FLA
TEMPORARY	TEMPORARY	PURPLE	Size to FLA

Table 2.2.K.1.f Wire Color Code

*** - For Motor Control Panels (MCP's) that are permitted to contain 480 VAC**

**** - Black 120 VAC wires are hot unless powered down via supplementary circuit protector. Red 120 VAC wires are hot based on the control logic state.**

L. Single Shielded Pair Cable:
   1. Tinned copper, nineteen strand, PVC insulated conductors, No. 16 AWG minimum, twisted with aluminum-polyester shield, stranded tinned 16 AWG copper drain wire and PVC black or gray outer jacket. Wire conductor colors shall be black (-neg) and red (+pos). 600 Volt Tray Cable (TC) rated.
   2. Product and Manufacturer: Provide one of the following:
      a. Belden Company (No. 9342).
      b. Okonite Company.
      c. Dekoron Wire and Cable Company.
      d. Or approved equal.

M. Wire Terminations:
   1. Terminate all field and internal component wiring using insulated ferruled connectors attached with manufacturer's recommended tool.
   2. Excessive stripping of the wire so as to allow bare wire outside the insulated ferrule is not permitted.
   3. Utilize insulated double ferruled connectors wherever two wires terminate on the same terminal block connection.
   4. Product and Manufacturer: Provide one of the following:
      a. Phoenix Contact – Clipline
      b. Thomas & Betts
      c. Weidmuller

N. Terminal Blocks:
   1. General
      a. Numerically code terminals utilizing terminal block manufacturer's marking system. Information must be printed directly on the terminal label. Sticky back labels are not permitted.

b. Terminal blocks must be DIN rail mountable with screw clamp connections. Spring cage connections are not permitted.
c. Double level terminal blocks are permitted for use with signals on ATB only.
d. Terminals used for analog signals on ATB shall be colored blue.
e. Terminal block jumpers must be connected via screw clamp. Screw clamped comb jumpers are permitted. Plug in jumpers are not permitted.

2. Product and Manufacturer: For each terminal strip type provide one of the following:
   a. Power Terminal Block (PTB)
      1) Phoenix Contact, Type UK 5 N, Color Gray, Model # 30 04 36 2
      2) Allen Bradley, Type 1492-J4, Color Gray, Model # 1492-J4
      3) Weidmuller, Type WSU 4, Color Dark Beige, Model # 1020100000
   b. Field Wiring Discrete Signal Terminal Blocks (TB1 and TB2)
      1) Phoenix Contact, Type UDK 3, Double Connection, Color Gray, Model # 27 75 37 5
      2) Weidmuller, Type WDU 4/ZZ, Double Connection, Double Level, Internal Connection, Color Dark Beige, Model # 1905060000
   c. Field Wiring Analog or Internal Wiring DC Power (ATB) - Single Level Terminal Blocks:
      1) Phoenix Contact, Type UK 3N BU, Color Blue, Model # 30 01 51 4
      2) Allen Bradley, Type 1492-J3-B, Color Blue, Model # 1492-J3-B
      3) Weidmuller, Type WDU 2.5 BL, Color Blue, Model # 1020080000
   d. Field Wiring Analog or Internal Wiring DC Power (ATB) - Double Level Terminal Blocks. Alternating double and single level ATB terminal blocks are permitted.
      1) Phoenix Contact, Type MBKKB 2,5 BU, Double Level, Color Blue, Model # 27 71 09 4
      2) Allen Bradley, Type 1492-JD3-B, Double Level, Color Blue, Model # 1492-JD3-B
      3) Weidmuller, Type WDK 2.5 BL, Double Level, Color Blue, Model # 1021580000

O. Surge Protection:
1. Provide DC surge protection with integrated varistor for all analog signal loops that are terminated to Programmable Logic Controllers provided in accordance with Specification Section 17262 – Programmable Logic Controller, Software and Programming.
2. Provide maintenance free, self-restoring surge protection to protect the electronic instrumentation system from surges propagating along the signal and power supply lines. Device shall be removable without interrupting the circuit
3. Provide a separate surge protector for the positive and a separate surge protector for the negative polarity of each loop.
4. Mount the surge protectors on the ATB.
5. Ground the surge protectors to the panel DC ground bus.
6. Label the surge protectors in sequential order starting with the ATB signals.
7. Required Features:

a. Amp Rating: Compatible with working voltage and current of device being protected.
b. Voltage Rating: Compatible with the working voltage of protected device.
c. Reaction Time: nanosecond range

8. Product and Manufacturer: Provide one of the following:
   a. Phoenix Contact
   b. Advanced protection Technologies
   c. EDCO
   d. Or approved equal

P. Wireways:
1. General:
   a. Mount wireways using stainless steel bolts. Drill and tap the sub-panel to accommodate the bolts.
   b. Color to be Gray or White throughout the entire panel. Provide only one color.
   c. All wireways to include cover.
   d. Wireway covers to be labeled as per section 2.2.B
2. Product and Manufacturer: Provide one of the following:
   a. Panduit
   b. Thomas & Betts
   c. Or approved equal

Q. Motor Starters and Overload Relays:
1. Refer to Specification Section 16423 – Motor Control Centers or 16422 – Combination Motor Starters

PART 3 - EXECUTION:

3.1 EXTERIOR PANEL:

A. Component Layout:
1. Arrange associated control and indication devices for a particular part of the process in close proximity to each other.
2. Mount indicating lights above control switches and push buttons.
3. Standard component spacing is 3 ½" center to center and 3 ½" above and below. It is acceptable to use more space if required, but spatial consistency must be maintained.
4. Maximum height for panel exterior-mounted devices is 6'-0" from the floor. Minimum height for panel exterior-mounted devices is 3'-0" from the floor.
5. Locate alarm horn at the top of the panel. The alarm horn may be located above 6'-0" device height limitation.
6. Unless otherwise noted; route field wiring through the bottom of the enclosure. Provide watertight conduit openings.

B. Exterior Panel Nameplates
   1. General
      a. Refer to Section 2.1.D for material and size requirements.
      b. Provide specific panel identification on nameplates derived from the CONTRACT SPECIFICATIONS and DRAWINGS.
      c. Obtain ENGINEER approval for panel identification for panels that are not identified in the CONTRACT SPECIFICATIONS and DRAWINGS.
   2. Panel Manufacturer Identifier and Power Requirements Nameplate (NP-1)
      a. Mount nameplate in the upper left corner of the panel front.
      b. Provide the following information for each circuit feeding the panel.
         1) The first line indicates the name of the manufacturer, location and phone number of who assembled the panel.
         2) The following lines:
            a) Include panel voltage, current, phase, frequency, short circuit current rating for each panel feed.
            b) Provide switchboard name and circuit number for each circuit feeding the panel.
            c) Refer to figure 3.1.B.2

MITCHELL & SONS, TOLLESON, AZ - (602) 555-1212
120 VAC, 0.5 AMPS, 1Ø, 60HZ, SCCR 5KA, FED FROM LP-34, CIRCUIT 6
120 VAC, 7.5 AMPS, 1Ø, 60HZ, SCCR 8KA, FED FROM LP-34, CIRCUIT 8

Figure 3.1.B.2

Panel Manufacturer Identifier and Power Requirements Nameplate (NP-1)

   3. Panel Identification Nameplate (NP-2)
      a. Mount panel identification nameplate in the top, center of the panel.
      b. Provide the following information:
         1) The first line of text is an abbreviation of the panel as shown on the CONTRACT DRAWINGS.
         2) The second line of text on the nameplate is used to spell out the process abbreviation.
         3) Refer to figure 3.1.B.3.

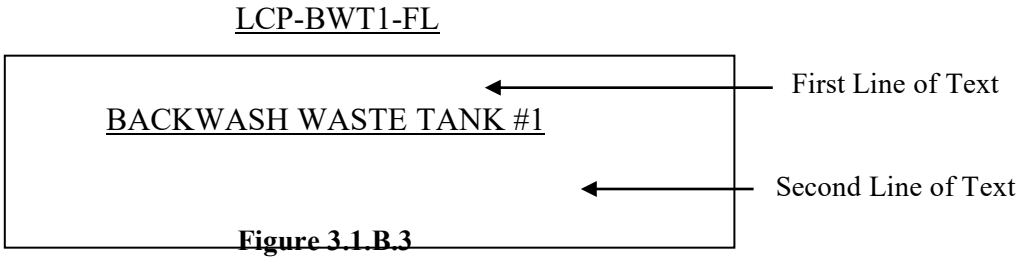

Figure 3.1.B.3

Panel Identification Nameplate (NP-2)

4. Panel Component Nameplates
   a. Mount nameplates above all control and indicating devices.
   b. Provide the following information:
      1) The first line indicates the instrument device loop identifier and number as shown on the DRAWINGS.
      2) The second line identifies the system equipment that the component is associated with.
      3) The third line identifies the control position, condition of the equipment or the alarm state being monitored.
      4) Refer to figure 3.1.B.4

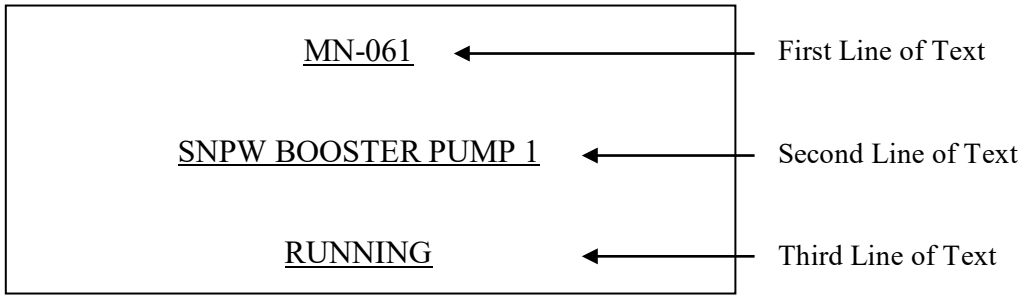

Figure 3.1.B.4

Panel Component Nameplates

3.2 INTERIOR PANEL

A. General:
   1. All Wall Mounted Panels - Where conduit enters the panel, maintain a minimum of 4" clearance from any device or wireway to allow room for routing of field wiring.

2. Concrete Pad or Floor Mounted LCP's and MCP's – Where conduits enter the panel through the concrete pad, maintain a minimum of 6" clearance from any device or wireway to allow room for routing of field wiring. Where conduit enters the panel sides or top, maintain a minimum of 4" clearance from any device or wireway to allow room for routing of field wiring.
3. Elevated Floor Mounted LCP's and MCP's - Where conduit enters the panel, maintain a minimum of 4" clearance from any device or wireway to allow room for routing of field wiring.
4. Concrete Pad, Floor Mounted or Elevated Floor Mounted ITP's - Where conduits enter the panel through the top or bottom, maintain a minimum of 6" clearance from any device or wireway to allow room for routing of field wiring.
5. Locate and install all devices and components so that connections can be easily made and that there is ample room for servicing each item.
6. Maintain a minimum 2'0" clearance between components mounted on side panels and components mounted on the opposing side panel.
7. Components mounted on the back panel are to be unobstructed by any components mounted on side panels.
8. Adequately support and restrain all devices and components mounted on or within the panel to prevent any movement.

B. Panel Incoming Power:
1. Panel power fed from lighting panels, or other sources with fused or circuit breaker protection, shall be wired to the Power Terminal Blocks (PTBs). Power sources entering the panel are to be provided with a separate neutral and ground. The PTBs shall have a separate terminal for the hot and neutral for each circuit. The ground to be terminated to the AC ground bar.
2. Mount the PTBs near the top left corner of the panel.
3. Multiple power sources may be required for each panel. Power requirements are identified on the CONTRACT DRAWINGS. The following additional power sources may be required for the panel.
   a. Control Logic Power and Light Fixture
   b. Air Conditioning
4. Arrange the terminal strip in an orderly manner with circuit conductors grouped together. For instance, terminate the hot and neutral conductors on consecutive terminals. Label terminals and internal wiring as H1 and N1 (Control Logic), H2 and N2 (Air Conditioning). Identify each additional source in sequential order beginning with H3 and N3.
5. Terminate all incoming power on one side of the terminal strip.

C. AC Power Distribution:
1. Identify the wire extending from the PTB to the supplementary protector as H1 and H2, etc. Using H1 as an example; the wire terminated to the line side of the supplementary protector is labeled H1, the wire terminated to the load side of the supplementary protector is labeled as L1-1.
2. If L1-1 passes through an additional supplementary protector to feed panel components, this supplementary protector can be shown on the drawings in a

horizontal or vertical position on a schematic rung and the wire terminated to the line side of the supplementary protector is labeled L1-1. The wire terminated to the load side of the supplementary protector is labeled L1 – (the Supplementary Protector #) and the wire color is black.

3. If the panel controls multiple pieces of equipment, such as two pumps with separate control circuits, provide a supplementary protector for each control circuit.
4. Powering 120 VAC field 4-wire instruments from the panel is not permitted.

D. DC Power Distribution:
   1. Mount DC power supplies near the top right of the panel. Mount fuses associated with the power supply in close proximity to the power supplies.
   2. Identify terminals used for DC power distribution as PTB-DC.
   3. Provide a fuse for each analog loop that loop power is provided by a power supply located in the panel.

E. Grounding:
   1. AC Ground:
      a. Provide the AC ground bus bar with cage type or screw terminals installed near the bottom of the back panel with extended mounting bolts.
      b. Provide adequate metal to metal contact between the AC ground bus bar and the back plane.
      c. Connect all AC power sources and devices to ground at this ground bus.
      d. Connect all panel enclosure doors to the AC ground bus.
      e. Connect all side panels to the AC ground bus.
      f. Provide a connection point on the ground bus for connection to the ground grid system.
   2. DC Ground:
      a. Install the isolated DC grounding bus bar with cage type or screw terminals installed near the bottom of the back panel at a minimum distance of 6” from the AC ground bus.
      b. The isolated grounding bus bar consists of two non-conductive mounting blocks with a single copper grounding bar attached between them.
      c. Connect all shields (SH) requiring loop grounding in the panel from the analog signal terminals to the DC grounding bus bar.
      d. To avoid ground loops, connect analog cable signal shields to ground at one location only, preferably in the LCP, MCP or ITP; not in the field. Maintain consistency for the termination point of signal shield for all analog signals.
      e. Provide a connection point on the ground bus for connection to the ground grid system.
      f. Figure 3.2 illustrates a typical ground system within a panel. The illustration depicts the physical terminations of the ground wires in the panel**.** Ground Conductor AWG size to ground grid system shall be as stated in Specification 16061 – Grounding Systems.

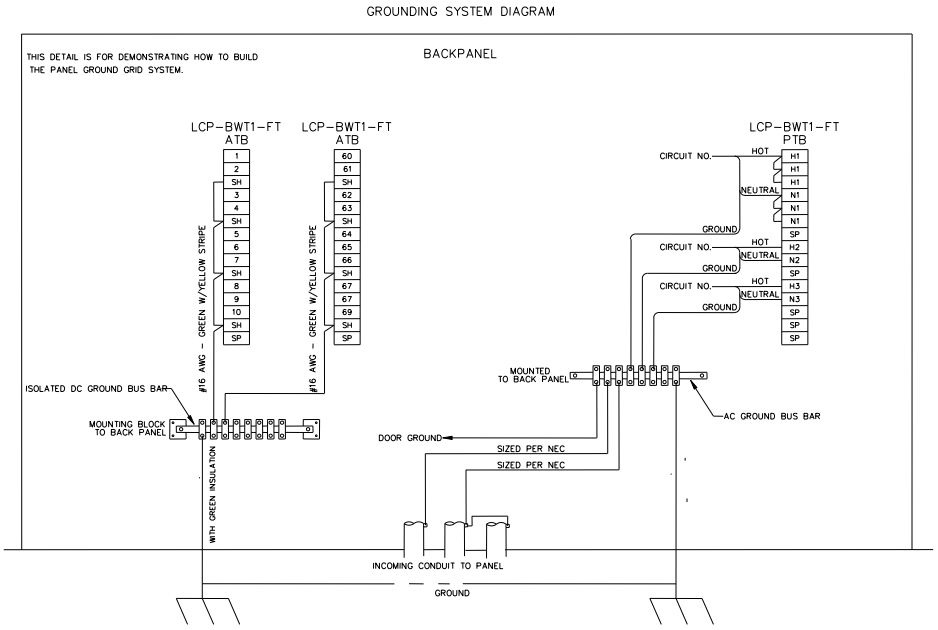

Figure 3.2

Typical Grounding Systems

F. Circuit Protection:
   1. Provide an isolating supplementary protector for each group of control logic. For example: the start, stop and reset control circuit for Pump #1 has a dedicated supplementary protector supplying power to the control logic. Pump #2 requires a separate isolating supplementary protector for the control logic.
   2. Provide an isolating supplementary protector for each component requiring 120 VAC power.
   3. A supplementary protector is not required for control circuits powered from a fused control power transformer in an MCP.
   4. Size supplementary protector to handle the connected load.
   5. Mount supplementary protector next to the PTBs near the top left corner of the panel.
   6. Provide an auxiliary contact for each supplementary protector. Wire each auxiliary contact from the supplementary protector in series to one "Power fail' relay. Send one Power Fail status to the Computer Control System.

G. Internal Panel Wiring:

1. Route all internal wiring using wireways. Terminate all internal wires on one side of the terminal blocks. The opposite side of the terminal block shall remain available for field wires.
2. Where wires pass through panel walls, provide suitable bushings to prevent cutting or abrading of insulation.
3. Adequately support and restrain all wiring runs to prevent sagging or other movement. Wires extended from the control logic to the panel door devices are to be wrapped in plastic protective wire wrap designed for this purpose.
4. Wire splicing is not allowed at any time.
5. Utilize two wires (hot and return leg) with field wiring for each field input. It is not acceptable to utilize one common Hot for multiple field inputs.
6. Terminate wires with an insulated ferrule type crimp connector. Excessive stripping of the insulation to allow bare wire strands between the insulation and the ferrule is not permitted.
7. Orientate wire labels on the individual conductor or cable so that wire labels are legible without having to twist or move the connectors. Securely heat shrink the labels around the conductor. Label wires or cables with the number assigned in the panel documentation. Refer to Section 2.2.K.1.e for wire label materials.
8. DC wiring for analog and discrete field or Computer Control System signals that enter or leave the panel are to be terminated on the Analog Terminal Block (ATB).
9. AC wiring for discrete field signals that enter or leave the panel are to be terminated on the Terminal Block 1 (TB1).
10. AC wiring for discrete Computer Control System signals that enter or leave the panel are to be terminated on Terminal Block 2 (TB2).
11. The terminal blocks (TB1, TB2 or ATB) can be mounted on the left or right side panels.
12. Provide a minimum of 10% spare terminal DIN rail space per terminal strip.
13. Signals from the field that enter the panel and only pass through the panel from the field to the Computer Control System require internal wiring from TB1 to TB2.
14. Arrange all control wiring associated with a particular piece of process equipment together on adjacent terminal blocks.
15. Identify wire number by the schematic rung numbers. Label TB1 and TB2 terminals with the rung number associated with the internal wire number connected to the terminal. Label ATB terminals in sequential order starting with the number 1. Identify analog shield terminations with an “SH” on the terminal block.
16. Multi-conductor cables of two pair or more shall have the outer cable insulation removed before entering the wireway.
17. Route all DC power and analog signals at a minimum of six inches from AC power and controls. When the six inch minimum distance is not available, provide a metallic barrier that extends 3” beyond the tallest wireway between the analog and discrete wireways.

H. Wireways:

1. Mount wireways from the internal panel components and terminal blocks with a minimum 2" spacing.
2. Arrange wireways to maintain a six inch minimum distance between analog and discrete circuit wiring.
3. Provide wireways for all field wiring. Arrange wireways to allow field wiring to enter from the top or bottom of the panel.
4. Align wireways between back and side panels.
5. Install a wireway on both sides of each terminal strip.
6. Size wireways to prevent conductor fill from exceeding 50% of the interior cross-sectional area of the wireway.
7. In addition to the above requirements, for ITP's, wireways are not to be common for two terminal strips. Each terminal strip shall have a dedicated wireway on each side of the strip.

I. Control Logic:
1. The Start commands are to be designed utilizing normally open contacts from pushbuttons and/or the Computer Control System and shall be of a momentary signal that will require a seal circuit to maintain operation. Constant signals from positions switches are not allowed unless noted on the CONTRACT DRAWINGS.
2. All system failure, safety logic control devices or normal operations that are intended to cause the equipment to stop are to be wired in series with the start seal circuit. The unsealing of the start command on any fault or normal operation that causes the equipment to stop will require another start command to reseal.
3. Provide interlocks for the control functions of Local and Computer Modes in series with the Start and Stop logic. Provide a closed switch or relay contact to the Computer Control System to identify when the equipment is in Computer Mode.
4. Provide control logic of voltage 120 VAC. Exceptions must be approved by OWNER
5. Use power relays when control relay contacts are insufficient for the designated load.
6. Terminate the "Hot" conductor on the common of the switch or relay contact.
7. Control alarm logic shall be wired in a fail-safe mode from the field device to the panel circuitry to alarm when a field wire has failed.

3.3 PANEL DRAWING DOCUMENTATION

A. General:
1. Files of the title block, panel symbols for front and internal sub-panel elevations, terminal strips, control schematics, analog loops, etc. are available in hard copy and AutoCAD .dwg format from the OWNER upon request through the ENGINEER via Example Panel Drawing Packages and Drawing Templates.
2. Provide drawing copies in the following format:
   a. Hard Copy - B Size - 11" X 17"
   b. Hard Copy - D Size - 22" X 34"

c. Soft Copy in .DWG

3. The panel drawing documentation package consists of the following drawings types arranged in the following order.
   a. Cover Sheet
   b. Symbols and Legends 1 – Exterior and Interior Panel Symbols
   c. Symbols and Legends 2 – Schematic Symbols
   d. Front Panel Elevation
   e. Interior/Sub Panel Layout
   f. Terminal Strip Drawings
   g. Control Schematics
   h. Analog Loop Diagrams
4. Drawing Scale:
   a. Provide Front Elevation and Interior/Sub Panel Layout Drawings proportionately correct and to scale. Create all drawings on a D Size layout.
5. Border and Title Block:
   a. Provide each drawing with a border and title block information.
   b. Utilize the border and title block as provided in the Drawing Templates referenced in Section 3.3.A.1.

B. Panel Drawing Types:
   1. General:
      a. Provide a complete documentation package for each panel consisting of the drawings in the order listed in Section 3.3.A.3.
   2. Cover:
      a. Cover sheet for the panel documentation shall include the following information.
         1) Located on the left half of the sheet to include the Manufacturers Name, Address, Phone Number, Web Address, Project Reference Number and UL508A Certification Number.
         2) Located on the right half of the sheet include the title “City of Phoenix” “Water Service Department” and the project title, City of Phoenix project number, the panel full title, the panel abbreviation, the facility area in which the panel exists, submittal date, volume number and sheet count.
   3. Symbols & Legends
      a. Utilize the Symbols and Legend sheets as provided by the OWNER upon request from the ENGINEER.
      b. Additional symbols may be added if an existing symbol on the Symbol and Legend sheets does not exist.
   4. Front Elevation Drawing
      a. The Front Elevation drawing illustrates the arrangement of the panel and position of the devices on the front face of the panel.
      b. Provide panel dimensions in inches. Provide dimensions for height, width, and depth. If the panel is small in size, the Front Elevation Drawing and Internal layout Drawing can be combined on one drawing.
      c. Provide the nameplate schedule on the Front Elevation drawing.
      d. Device Callouts

1) Device callout hexagons are utilized to reference a device to the bill of materials. Place the bill of material item number inside the hexagon.
2) Provide a leader from the hexagon that will point to the device.
3) For a typical of multiple devices of the same type, only one device callout is necessary.

5. Interior Sub Panel Layout:
   a. General:
      1) The Interior Sub Panel Layout drawing identifies the individual interior components and their physical location.
      2) Draw all components within the panel to scale.
      3) Include all interior sub panels if the panel has sub panels on the side walls.
   b. Provide the following information on the Interior Sub Panel Layout Drawing. Utilize the formats provided on the Drawing Templates. The information can be shown on a second sheet if needed due to drawing clutter.
      1) Bill of Materials
         a) Include all devices on the Front Panel Elevation and the Interior Sub Panel(s) Elevation.
         b) Include items that are not specifically shown on the Front Panel Elevation or the Interior Sub Panel Layout drawing, such as wire size, color and type, on the bill of materials.
         c) The utilization or insertion of Microsoft Excel files for the Bill of Materials is not allowed.
      2) Fuse Schedule
      3) Supplementary Protector Schedule
   c. Label and identify all devices, including terminal strips, relays, fuses, timers, power supplies and other special components on the drawing.
   d. For unique devices not shown on the Symbols and Legend Sheets, use rectangles and squares with the appropriate dimensions of the device.
   e. Device Callouts
      1) Device callout hexagons are utilized to reference a device to the bill of materials. Place the bill of material item number inside the hexagon.
      2) Provide a leader from the hexagon that will point to the device.
      3) For a typical of multiple devices of the same type, only one device callout is necessary indicated by (typ) near callout hexagon.
6. Terminal Strip Drawing:
   a. General:
      1) Terminal Strip Drawings provides locations for wiring terminations from field devices and other equipment external to the panel.
      2) Display the wiring connections exactly as they are physically installed. For example, if field wiring is terminated to the left side of the terminal strip, the terminal strip drawing displays the wiring connections to the left side of the terminal block.
      3) There are 6 different types of terminal strips and each has a specific function. The following is a brief description of each:
         a) For LCP's and MCP's:

i. Power Terminal Block (PTB) – Power supply/supplies to the panel (120 VAC or higher). Identify terminal block number with the wire number assigned in the control logic drawings. Identify power sources with the originating panel, voltage and circuit number.
ii. Field Wiring Discrete Signal Terminal Blocks (TB1) – Discrete field inputs and outputs to/from the panel. Identify terminal block number with the rung number assigned in the control logic drawings.
iii. Field Wiring Discrete Signal Terminal Blocks (TB2) – Discrete inputs and outputs to/from the Computer Control System. Identify terminal block number with the rung number assigned in the control logic drawings.
iv. Field Wiring Analog (ATB) or Internal Wiring DC Power Terminal Blocks - Field or Computer Control System Analog inputs and outputs to/from the panel, including 4-20 mA, 1-5 VDC, thermocouple or Resistance Temperature Detectors (RTD's). Identify terminal block number with consecutive numbers starting with number 1. The shield wire terminal block is to be label "SH".

b) For ITP's:
i. TB-A thru Z – Discrete field inputs and outputs to/from the panel.
ii. ATB-A thru Z – Analog inputs and outputs to/from the panel.

4) It is acceptable, if space available, to combine TB1, TB2, ATB and PTB on a single terminal strip drawing.
5) Identify spare terminals with an "SP" inside the rectangle.
6) Display terminals in the order they appear in the panel.
7) Place field wire labels on each line extending toward the terminal. Obtain this information from the cable and conduit schedules. If wire labels are unavailable, place seven "X's" where wire tag normally resides. Provide this information prior to final deliverable of the Operations & Maintenance Manuals.
8) Signal description consists of 3 lines of text. Center the text next to the terminals.
a) The 1st line of text lists the Equipment Name.
b) The 2nd line of text is for the Signal Function.
c) The 3rd line of text is the Signal Loop Number, if applicable.

7. Control Schematic:
a. General:
1) Control Schematics show the controls associated with pieces of process equipment and provide a visual depiction of the majority of control wiring.
b. Control Schematic Components:
1) Power Rail:
a) Represent the power rail with two parallel vertical lines that extend vertically down the schematic.

b) Each drawing includes two sets of power rails separated by 2.5".
c) Identify each power rail with the wire number such as L1 at the top and bottom of each power rail.
d) The left power rail represents the "Hot" side of the power source. The right power rail represents the "Neutral" side of the power source.

2) Power Source:
a) Identify power source(s) with the originating panel, voltage and circuit number between the "Hot" terminal and "Neutral" terminal on the first rung of the portion of the schematic for each source.
b) Indicate the terminals from the PTB providing the source and neutral powering the rail.
c) A supplementary protector or fuse is displayed in the power rail directly below the power source (Hot) terminal. Label the supplementary protector or fuse with the supplementary protector or fuse number and current rating.
d) Power layout for LCP's:
i. In the first portion of the schematic, display power to the general purpose receptacle and panel light.
ii. In the second portion of the schematic, display power to the air conditioner and/or heater.
iii. In the third portion of the schematic, display the power to the control logic.
iv. See Sections 3.2.B Panel Incoming Power and 3.2.C AC Power Distribution.
e) Power layout for MCP's:
i. The first portion is for the typical 480 VAC motor control circuit with starter and disconnect, the next sections are the same as for the LCP's.

3) Rung Number:
a) Rung numbers are used to identify the location and cross referencing of devices within the schematic and provide a practical means of labeling conductors and terminals within the panel.
b) Rung numbers are a sequential series of numbers starting with number 1. Locate the numbers vertically along the left side of the "Hot" power rail.
c) Rungs are to be spaced on 0.5" centers based on a D Sized drawing.

4) Wire Numbering:
a) On the downstream side of the first device on a rung, the wire number takes the rung number appearing to the left of the power rail. If a second device is located in the circuit, the wire number to the right of the second device takes the rung number, but is appended with an "A". The wire number to the right of the third device is appended with a "B", and so on.
b) When the electrical connection originated on the previous rung, the wire numbers continue to use the previous rung number as the base.

c) Connections to the power neutral rail take on the power neutral rail's wire number N#.

5) Electrical Connections:
   a) Represent electrical connections as a solid small circle where two or more wires interconnect.
   b) Represent electrical connections as a hollow small circle where wires terminate to a device.
6) Electrical Wiring:
   a) Electrical wires or circuits are represented by horizontal rungs that connect terminal blocks, relays, contacts and all other components used in the electrical schematic.
   b) Space the schematic electrical wiring every other rung at a minimum.
   c) Identify each wire with the rung number as the wire number.
   d) Label each wire with the conductor insulation color below each electrical wire. Refer to Table 2.2.K.1.f.
   e) Indicate electrical wiring that is external to the panel with dashed lines.
7) Device Labeling:
   a) Device symbols in the schematic for field devices, pilot lights, switches, push buttons etc. requires two lines of text above the device and one line of text below the device to describe the usage of the device.
      i. The first line of text above the device is the name of the equipment the device is associated with.
      ii. The second line of text above the device is the control function of the device.
      iii. The line of text under the device is the loop number.
   b) Relay and timer symbol labels are to be identified with consecutive number starting with the number 1 or the rung number. For relay coils and contacts, identify the relay base terminal connection. Normally open or normally closed contacts refer to the de-energized or "off the shelf" state.
   c) Symbols in the schematic for contacts of relays, timers, etc. require two lines of text above the contact and two lines of text below the contact to describe the usage and coil reference of the contact.
      i. The first line of text above the contact is the name of the equipment the device is associated with.
      ii. The second line of text above the device is the control function of the device.
      iii. The first line of text under the device is the relay or timer number to reference the relay or timer in the schematic.
      iv. The second line of text under the device is the rung number of the relay or timer to reference where the relay or timer is located in the schematic. If using the rung number for the relay or timer coil, the rung number under the contact is not required.

v. For relays and timer contact references, at the right of the neutral power rail, the schematic rung number location of all associated contacts is shown. If the contact is normally closed, underline the reference number. If a contact is unused, "SP" is shown.

8) Field Contacts:
   a) Show Field Contacts connected to their respective TB1 or TB2 Terminals.
   b) The connection lines from the contact to the terminal are dashed to designate they originate from outside the panel.
9) Selector Switches:
   a) Always show the switch in the far-left position, the switch contacts are shown as either opened or closed in this state. If they're in the closed state, the contact is shown closed, indicated by a line shown below and touching the two side small circles. If the contact is open in this position, a line is drawn above the two side small circles, but not touching them.
   b) Show each position of the switch directly above its respective location on the switch. This indicates whether it is a two, three, four, or more position (pole) switch, and shows what the nameplate on each position will read.
   c) To indicate which positions the contact is closed, show a contact legend in parenthesis below and to the right of the contact. If the contact is closed in a position, an "X" is shown in the order of the contact position in which it is closed. If the contact is open in a position, an "O" is shown.
   d) When a selector switch is continued onto another sheet or further down on the same sheet, the continuation note is shown below the selector switch. Where the switch is continued, the same note appears, but on the top of the contact.
10) Push Buttons:
   a) Represent the push button contact in its "off the shelf" state.
11) Terminals:
   a) Terminal numbers are dependent upon the specific rung number that they appear in the schematic logic. As a horizontal electrical connection is followed from left to right, the first terminal number takes on the number of the rung. The second terminal number also takes the rung number but is appended by the letter A, the third by the letter B, and so on.
12) Programmable Logic Controller:
   a) Panels that contain a Programmable Logic Controller (PLC) require connection information for the PLC I/O modules.
      i. Utilize the PLC drawings as provided in the Drawing Templates referenced in Section 3.3.A.1.a.
   b) Module Layout:
      i. Represent the module with a 1 1/2" wide vertical rectangle with a length suitable to encompass a maximum of 16 channels or 8

analog per section based on type of module. Two cards can be shown per sheet.

ii. Display field wiring (inputs) including TB1 and field device connections with a description on the left side of the module symbol.
iii. Label the module with model number, input voltage, rack number and slot number above the module symbol.
iv. Number each screw terminal per manufacturer's data.
v. Display the associated PLC register address with each signal.
vi. Identify the positive and negative legs of the analog cable.
vii. Include all required jumpers for signal type and all 120VAC and 24VDC power requirements.

13) 480 Volt Equipment:
   a) Provide the motor horsepower, full load amps and motor identification.
14) Contact Development:
   a) The last sheet of the control schematic displays contacts for internal panel relay contacts that connect with external field equipment or the Computer Control System (CCS).
   b) Organizes into two sections. The first section lists all contacts extending to the CCS. Title this section "Contacts to CCS". The second section lists all contacts extending into the field equipment external to the panel. Title this section "Contacts to Field". Group multiple contacts related to a single piece of equipment together.
   c) Each contact includes a signal description and its associated relay number and relay rung number location. Device signals require the appropriate symbol from the Schematic Legend Sheet.

8. Analog Loop Diagrams:
   a. General:
      1) The analog loop diagram only displays the portion of the instrument loop that passes through a particular panel.
      2) The analog loop diagram displays the connections between field instruments, panels and the CCS.
      3) Analog loop diagrams are reserved for analog signals and control loops, but may be used to show complex connections for a particular instrument or device.
      4) Divide each loop into three different segments.
         a) The left segment is "FIELD" connections. This segment provides information on terminations external to the panel (i.e., connected panels, instrument transmitters). If the first segment is another panel, the panel name replaces the "FIELD" label.
         b) The center segment is the internal panel wiring and controls.
         c) The right segment information represents output or input signals to downstream panels or the CCS.
      5) Identify shield grounding location.

6) Identify surge protection devices for each signal. Include surge protection for positive and negative leads. Utilize the surge protection block symbol from the legends and symbols sheet.
7) Identify the cable number, wire color and polarity for each cable in the loop.

3.4 INSTALLATION

A. Install equipment in conformance with NEC. Mounting panels on handrails is not allowed. Mounting panels below grade or in pits will require exception from the OWNER.

B. Unless otherwise noted, install indoor free-standing panels on 4-inch concrete pad. Extend pad 4-inches beyond outside dimensions of base, all sides. Lay grout after panel sills have been securely fastened down.

C. Unless otherwise noted, install outdoor free-standing panels on a reinforced concrete pedestal:
   1. Minimum Thickness: 8-inches with No. 4 steel reinforcing bars at 12-inches on centers, each way.
   2. Minimum Size: 4-inches larger than outer dimensions of base, all sides.
   3. Provide excavation and backfill work in conformance with Section 02315, Structural Excavation and Backfill.
   4. Provide concrete work in conformance with Section 03300, Cast-In-Place Concrete.
   5. Seal the contact surface between the panel base and concrete surface with a gasket, gasket sealant and along the outside perimeter of the panel using RTV sealant.
   6. Install anchor bolts and anchor in accordance with Section 05051, Anchor Bolts, Toggle Bolts and Concrete Inserts.

D. Elevated Panels with floor stands:
   1. When installing conduits through bottom, utilize bushings to retain the NEMA rating of the panel.

E. Install each item in accordance with manufacturer's recommendations and in accordance with the Contract Documents.

3.5 RECORD DRAWINGS:

A. Maintain a set of red-line panel drawings to reflect changes or deviations that occur during installation, start-up and commissioning and incorporate these deviations into the final Operation & Maintenance Manual.

B. Provide record drawings in accordance with Section 01782 – Record Documents

3.6 SPARE PARTS AND TEST EQUIPMENT

A. Furnish and deliver the spare parts and test equipment as outlined below, identical and interchangeable with similar parts furnished under this Specification. Comply with the requirements of Section 01783, Spare Parts and Maintenance Materials.

B. Pack spare parts in containers suitable for long term storage, bearing labels clearly designating the contents and the pieces of equipment for which they are intended.

C. The following constitutes the minimum spare parts:
   1. Five of each type of control relay for each 40 or less furnished for this Contract.
   2. One replacement power supply for each type and size furnished for this Contract.
   3. One per ten (two, if fewer than twenty) of each type of panel mounted instrument including lights and pushbuttons.
   4. One dozen of each type and size of fuse used in panels and instruments.

D. The following constitutes the minimum test and calibration equipment:
   1. All tooling required to insert, extract and connect any internal or external connector, including edge connectors.
   2. All special calibration equipment required for system calibration.

3.7 TESTING AND ADJUSTMENTS:

A. Perform system testing and make any adjustments necessary in accordance with this Section and Section 17001, Process Control System General Requirements.

B. Perform power supply, voltage adjustments to tolerances required by the appurtenant equipment.

C. A Factory Acceptance Test shall be conducted before the panel is shipped to the site. The Factory Acceptance test shall be witnessed by the ENGINEER and OWNER. The Factory Acceptance Test Report listed in Specification Section 01331 – Reference Forms – Form 17260-A shall be utilized to document the test.
   1. The panels require Factory Acceptance Test to be witnessed by ENGINEER and OWNER.
   2. Provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to perform factory testing, before shipment, at the manufacturer's facility to verify that system components are functioning properly and that they meet the functional and performance requirements of the Contract Documents.
   3. Submit information on factory testing procedures to verify that testing shall fulfill the requirements as specified herein. Submittal shall be made at least two months in advance of any scheduled testing and shall include dates of scheduled tests.
   4. Notify ENGINEER, in writing, at least four weeks before expected initiation of tests. OWNER and ENGINEER may elect to be present at CONTRACTOR'S facilities during operational test of system equipment, either for individual units

or as an integrated system. Presence of OWNER and ENGINEER during testing does not relieve CONTRACTOR from conforming to the requirements of the Contract Documents and shall in no way imply acceptance of the equipment.

D. System Hardware Operational Testing
   1. All input/output devices and components shall be tested to verify operability and basic calibration.
   2. All system hardware components equipment shall be tested to verify proper operation of the equipment as stand-alone units. Test shall include, but not be limited to, the following:
      a. AC/DC power checks.
      b. Power fail/restart tests.
      c. Diagnostics checks.
      d. Test demonstrating that all specified equipment functional capabilities are working properly.
      e. All system components shall be tested to verify that communication between units is working properly.

3.8 MANUFACTURER'S SERVICE

A. Provide the services of qualified factory-trained service representative to check and approve the installation of the panel(s).

B. The factory trained service representative shall be provided for installation supervision, start-up and testing services. The representative shall make a minimum of four (4) visits to the site to approve the completed installation and to perform start-up testing of the equipment. The representative shall coordinate each visit with the ENGINEER prior to arrival on the site. The representative shall test operate the system in the presence of the ENGINEER and verify that the equipment conforms to requirements. The representative shall revisit the job site as often as necessary until the installation and testing is entirely satisfactory.

C. The factory trained service representative shall be provided for operation and maintenance personnel training services. The representative shall make a minimum of three (3) visits to the site to perform the services as described under Section 01821, Instruction of Operations and Maintenance Personnel. The representative shall coordinate each visit with the ENGINEER prior to arrival on the site.

D. For the factory trained service representative, all costs, including travel, lodging, meals and incidentals, shall be considered as included in the bid price.

E. Warranty: Minimum 1 year from final startup date or as specified in N.T.S. or in the contract specifications, whichever is longer.

++ END OF SECTION ++

SECTION 17262

PROGRAMMABLE LOGIC CONTROLLER, HARDWARE, SOFTWARE, AND PROGRAMMING

PART 1 GENERAL

1.1 SCOPE

A. Contract documents illustrate and specify general requirements of the Programmable Logic Controller (PLC), Operator Interface Terminal (OIT), hardware, software, networking, and programming. This document does not necessarily show or specify all components, wiring, or accessories required for a completely integrated system.

B. Provide all labor, materials, equipment, documentation, furnish, install, calibrate, test, start-up, program, configure, commission, and place into satisfactory operation of all PLCs, OITs, networking hardware, software, and programs.

C. Conform the design and programming of all PLCs, OITs, software, and programs to the specifications herein.

D. Provide all necessary tools, such as cabling, software, etc.., as required to fulfill the programming requirements of the contract documents.

1.2 COORDINATION

A. Coordinate the installation of all items specified herein as required to ensure the complete and proper functionality of all PLCs, OITs, software, programs, networking, and accessories.

B. Provide all PLCs, OITs, software, networking, and programs to meet the functional requirements as detailed in Section 17051 – Computer Control System Process Control Descriptions as depicted in the CONTRACT DRAWINGS.

C. Install and wire all Inputs/Outputs (I/O) as specified in Sections 17260 – Control Panels.

D. Install PLCs or remote I/O in control panels with voltages of 120 VAC or less.

E. Relinquish all usernames and passwords to the OWNER, this includes but is not limited to all hardware, software, and programs. All usernames and passwords are the property of the OWNER.

F. Provide separate 120 VAC receptacles in the control panel for PLC hardware. Label each receptacle, i.e. “Fiber Optic Converter Use Only”. Provide an isolating supplementary protector for each receptacle.

G. Provide all PLC and OIT hardware and accessories with Heresite conformal coating, or equal protection, against hydrogen sulfide levels up to seven ppm.

1.3 DEFINITIONS

A. **PLC:** Programmable Logic Controller.

B. **OIT:** Operator Interface Terminal. This terminal is located in the field on a local control panel usually connected directly to a PLC. The purpose is to locally control the process or machine, for example a Magelis Screen.

C. **HMI:** Human Machine Interface. The City of Phoenix uses a desk top computer, Operator Workstation (OWS), which interfaces the operator with the entire process.

D. **DISTRIBUTED INPUT / OUTPUT (I/O):** Is generally when multiple processors control different section of a process using communication protocols, i.e. Modbus RTU, Modbus TCP/IP.

E. **REMOTE I/O:** One processor connected to several remote racks, drops, by parallel cables or network equipment.

1.4 QUALITY ASSURANCE

A. REFERENCE STANDARDS: PLCs, OITs, networking hardware, software, programs, and accessories must comply with applicable provisions of the following, except where otherwise shown or specified.

1. International Electrotechnical Commission (IEC).
2. American National Standard Institute (ANSI).
3. Institute of Electrical and Electronic Engineering (IEEE).
4. National Electrical Manufacturer’s Association Standards (NEMA).

5. Operational Safety and Health Administration (OSHA) Regulations.
6. National Fire Protection Agency (NFPA).
7. State and local code requirements.
8. Where any conflict arises between codes or standards, the more stringent requirement applies.
9. Provide all panel devices with the label of the Underwriters' Laboratory (UL), Inc. Document the UL/UR listed number on the Bill of Materials (BOM) of the control panel drawings.

1.5 SUBMITTALS

A. Submittals:
   1. The PLC submittal requirements and BOM are to be submitted with the control panel submittal package prior to the 90% design review. Reference Section 17260 – Control Panels.
   2. Provide the manufacturer's technical data sheets, cut sheets, and product literature for all PLCs, OITs, networking hardware, software, programs, and accessories. Clearly identify exact equipment and materials that are being supplied on the manufacturer's data sheets.

B. PLC Program Coordination Workshop:
   1. Conduct a program software coordination workshop with the PLC PROGRAMMER, ENGINEER, and OWNER prior to shipment of the equipment.
      a. Workshop Agenda:
         i. Review the control logic and function block programming styles.
         ii. Review the PLC I/O signal list.
         iii. Review the hardware configuration
         iv. Review the network configuration.
         v. Review the DNP3 configuration associated with the NOR module. This should include files from the M340 BMXNOR RTUconf Tool software.

vi. Review CONTRACT DRAWINGS and Section 17051 – Process Control Description.

b. Attendees:

i. PROGRAMMER/CONTROL PANEL SUPPLIER

ii. CONTRACTOR

iii. OWNER PROCESS CONTROL REPRESENTATIVE

iv. ENGINEER

v. DESIGN ENGINEER FIRM REPRESENTATIVE

vi. I&C INSPECTOR

vii. OWNER PROJECT MANAGER (OPTIONAL)

2. Conduct a minimum of a eight (8) hour workshop on site, unless stated otherwise. This workshop is to ensure that the software code, OIT screens, hardware configuration, and addressing are compatible with the OWNER'S system.
3. Provide four (4) hard copies and four (4) soft copies of all OIT and PLC programming with addressing, comments, and descriptions at a minimum of two (2) weeks prior to the workshop.

1.6 O&M MANUALS

A. Comply with the requirements of Section 01781 – Operations and Maintenance Data and the following:
1. Provide a hard copy of all PLC programs complete with comments and address descriptions.
2. Provide a USB Flash Drive containing a copy of the OIT and PLC program with complete annotated documentation. Remove any passwords and relinquish all rights of the program to the OWNER with READ/WRITE access.

PART 2 PRODUCTS

2.1 PROGRAMMABLE LOGIC CONTROLLERS

A. General:

UTILIZE THE SCHNEIDER ELECTRIC MODICON X80 I/O PLATFORM – ALL PART NUMBERS REFERENCED IN THIS DOCUMENT ARE SUGGESTIONS.

THE DESIGN ENGINEER SHOULD VERIFY THE BEST POSSIBLE MODULE PER THE MANFACTURE RECOMMENDATION.

1. Provide a M580 processor on a X80 I/O platform with the following functionality:
    a. All operational, protective, status, and alarm functions execute as described per Section 17051 – Process Control Description, 17260 – Control Panels and the CONTRACT DRAWINGS.
    b. Perform process control functions, data collection, communicate with other PLCs, and distribute process information along the local area network (LAN).
    c. Capable of stand-alone operation during any communication failure.
    d. Capable of downloading and uploading programs from a remote workstation over the LAN and locally programmed from a portable laptop computer.
    e. Field expandable to allow for the growth of the system by simple addition and configuration of hardware.
    f. I/O modules are capable of insertion and removal under power.
    g. I/O modules can only be inserted one direction to prevent improper installation of modules.
    h. Key all modules and connectors to safeguard against improper insertion of a module into the backplane slot.
    i. Each component must include a clearly visible faceplate with appropriate data such as the manufacturer’s model number and a brief description of the component’s functionality.
    j. Provide all cables and connectors as specified by the manufacturer. Assemble and install cables per the manufacturer’s recommendations.
    k. Provide configurable alarming capability. Each alarm point can be configured to display an alphanumeric message in the alarm buffer. The alarm buffer can be displayed from an OIT.
2. PLC Module Fusing:
    a. Provide each analog and discrete I/O module with at least one properly sized fuse per the manufacture recommendations.
3. Surge Protection:

a. Install the surge protection as stated in Guide Specification 17260 – Control Panels.

4. Virtual Private Network (VPN) access will NOT be granted for any programming, troubleshooting, testing, and/or support. If needed a PCTS laptop can be provided.

B. Chassis:

1. Backplanes and modules if applicable shall be the Hardened (H) model.
2. Backplanes will be Ethernet BME modules only:
   a. BME XBP 0400H (Ethernet)
   b. BME XBP 0800H (Ethernet)
   c. BME XBP 1200H (Ethernet) Slots 02, 08, 10, and 11 are NOT Ethernet.
3. General Chassis Layout:
   If the cabinet space permits provide a spare slot between the last communication module and each of the different types of I/O modules, i.e. communication module, spare dust cover, DI's, spare, DO's, spare, AI's, spare, AO's.

   a. Install the power supply in the first slot (CPS).
   b. Install the CPU to the right of the power supply.
      i. M580 requires two slots, 00 and 01.
   c. Install additional communication modules and specialty modules to the right of the CPU.
      i. BMEXBP 1200H (Ethernet Backplanes) Slots 02, 08, 10, and 11 are connectors for X-bus modules only, NOT Ethernet.
      ii. Treatment Plants require an additional communication module for redundancy. Use BMENOC0321C.
      iii. If multiple communication modules are required install them in this order.
         a. NOC
         b. NOR
         c. Specialty protocol for example, (BMEAHI0812H) HART
      iv. Install any specialty modules if applicable, to the right of the communication modules.

d. If a fiber module is required, install it in the last slot on the backplane, for example: in slot 07 on an BMEXPB0800H 8 slot Ethernet backplane.
e. Install all DI modules next, based on required spares leave an open slot if needed for an additional module. Install a dust cover in the empty slot, do not leave the slot empty. Use BMXXEM010.
f. Install all DO Modules to the right of the DI modules or open slot.
g. If backplane and cabinet space permit leave an open slot between the discrete modules and the analog modules.
h. Install AI modules next, based on required spares leave an open slot if needed for an additional module.
i. Install AO modules to the right of the AI modules, based on required spares leave an open slot if needed for an additional module.
j. If cabinet space permits upsize the backplane to meet the needs of the required spares and spaces between discrete and analog modules.

4. Remote I/O (RIO)
   a. Each backplane that does not contain the CPU will need:
      i. Ethernet capability
      ii. BME CRA 31210C (module)
      iii. Create a daisy chain loop using copper or fiber depending on the distance from the main backplane and the RIO backplane.
         a. A copper cable connection between two consecutive RIO backplanes cannot exceed 100m (328 ft.).
         b. A multi-mode fiber connection between two consecutive RIO backplanes cannot exceed 2.5km (1.5 mi.).
         c. A single-mode fiber connection between two consecutive RIO backplanes cannot exceed 15km (9.3 mi.).
         d. When the need for a fiber connection is required use the following hardware:
      i. BMX NRP 0200, multi-mode.
      ii. BMX NRP 0201, single-mode.

5. Dust Cover:
    a. BMX XEM 010

C. Power Supply:

1. Provide a chassis mounted power supply with the capacity to power the backplane, CPU, required modules, and similar future modules. Preferred but not limited to:
    a. BMX CPS 3500H
    b. BMX CPS 3020H

D. CPUs:

1. Provide one of the following M580 CPUs.
    a. BME P58 1020H
    b. BME P58 2040H
    c. BME P58 4040
    d. BME H58 2040H

E. Communication / Specialty Modules:

Confirm with the manufacture that this is the most accurate and current module for the application.

1. Provide the following modules for Ethernet TCP/IP. All Treatment Plant PLCs require at least one redundant Ethernet TCP/IP communication module.
    a. BME NOC 0321C, Gig Speed
2. Provide the following module for DNP3 or Serial RTU communication. All SCADA PLCs require a DNP3 communication module.
    a. BME NOR 2200H
3. Provide the following module for HART communications.
    a. BME AHI 0812H
4. Provide the following module for Thermocouples or RTD’s.
    a. BMX ART 0814H
5. Prove one of the following modules for High Speed Counting.

a. BMX EHC 0200H
b. BMX EHC 0800H

6. Provide the following module for serial RS232.
   a. BMX NOM 0200H

F. Discrete and Analog I/O Modules: Due to the many different types of modules and constant technology changes the design engineer will need to research the most appropriate module to satisfy the process description and 10% additional space requirements for future growth.
   1. Provide one of the following modules for Discrete Inputs.
      a. BMX DAI 1604H, 16 Input, 120 V AC
   2. Provide one of the following modules for Discrete Outputs.
      a. BMX DAO 1605H, 16 Output, 100..240 V AC
      b. BMX DRA 1605H, 16 Output, Relay
   3. Provide the following module for Analog Inputs.
      a. BMX AMI 0810H
   4. Provide one of the following modules for Analog Outputs.
      a. BMX AMO 0410H, 4 Output
      b. BMX AMO 0802H, 8 Output
   5. Provide the following module for Mixed Analog Inputs/Outputs.
      a. BMX AMM 0600H, 4 Input, 2 Output

G. Terminal Blocks and Wiring:
   1. Provide the required Terminal Blocks for each module.
   2. In addition to the 17260 – Control Panel requirements, ensure all thermocouples and resistive temperature devices (RTD) are wired per the manufacturer recommendations.
   3. Wiring spare I/O to the PLC module is not permitted.

H. PLC System Protection:

1. If the PLC circuit is backed up by a generator, then the PLC shall be backed by an uninterruptible power supply (UPS). A UPS shall provide emergency power between the time utility power is lost and the backup generator begins to provide power. The UPS systems shall be sized to supply power to the PLC equipment, communication modules, and switches within the PLC cabinet at full load. UPS systems shall provide status information to the IPM gold software through a network interface card (NIC). At a minimum the status information shall indicate if the UPS has faulted and when battery backup power is being used.

2.2 PLC SOFTWARE:

A. Acceptable PLC Programming Software:

1. Develop all PLC programming application utilizing the current version of Schneider Electric EcoStruxure Control Expert.

2.3 PLC PROGRAMMING:

A. Use the following approved integrator for programming (PLC/OIT and as specified):

1. Black & Veatch Corporation – (623) 340-0810 (Shawn Rohr – rohrsb@bv.com)

B. General PLC Software Set Up:

1. Approved protocols are: Modbus RTU, Modbus TCP/IP, DNP3, and HART.
2. If configuring specialty modules using third party software provide the software and file for the module being programmed.
3. Backup Copies & File Sharing: When transferring files to and from organizations, provide archive files (.sta) and exported files (.zef). The file name shall be capitalized with a short description of the area, project subject, and latest revision date separated with underscores.

   Examples:

   a. 6L-B1_02012020.sta = SCADA site 6L-B1 on February 1st 2020.
   b. VVWTP_TB12_01122019.zef = Val Vista WTP – Traveling Bridge 12 on January 12th 2019.
4. Processor Set Up:

   a. M580 Configuration:

i. Request OWNER Programmer to supply template file.
ii. Request OWNER Programmer to confirm latest firmware for applicable processors and modules.
iii. Request OWNER Programmer to supply latest DFB Library.

5. Naming Conventions:
   a. Physical Input/Output Variable/Alias Names
      i. Control Expert allows up to 32 characters for variable names, use as many characters as you need to adequately describe the variable. Use the descriptions from the P&ID drawings, which should match the computer control system tag names in the 17226.
   b. Code Section Names:
      i. First_Letter_Capital_Separated_By_Underscores
   c. Logical Variable Names:
      i. FirstLettersCapital+Suffix

         First part of suffix to indicate where the variable originates (PLC, OIT, CCS, or SCADA). Second part of suffix is the data type (Discrete, Integer, Real, or Word).

         Examples:

         VariableNamePD: A Discrete value that originates in the PLC.
         VariableNameOI: An Integer value that originates in the OIT.
         VariableNameCR: A Real value that originates in the CCS.
         VariableNameSW: A Word value that originates in the SCADA.

   d. Communication Networks:
      i. Module Location
         a. All_Caps_Ethernet_Port
         b. Example: CPU_Ethernet_Port or NOE_Ethernet_Port
6. Physical IO Data Types:
   a. For M580 PLCs
      i. Use Device DDTs with the naming convention as the default.
      ii. Assign an Alias' to each input/output used in the program.

7. Logical Data Types:
   a. Use only EDT variable types.
8. Addressing:
   a. Group addresses for sharing with other devices in a contiguous fashion for efficiency in communications. Submit any unusual addressing conflicts to the Lead UTS.
   b. Chart

Variable Type	Group Description	Data Type	Address Range
Discrete Inputs / Reads	Physical DI's	EBOOL	
	Module Status	BOOL	PCL0_d…MOD_HEALTH
	From SCADA/Field Device/CCS	EBOOL	%M001 - %M199
	From OIT	EBOOL	%M1000 - %M1199
Discrete Outputs / Writes	Physical DO's	EBOOL	
	Module Status	BOOL	PCL0_d…MOD_HEALTH
	To SCADA/Field Device/CCS/OIT	EBOOL	%M200 - %M999
Discrete Inputs / Outputs	Miscellaneous if necessary for internal R/W (DO or DI)	EBOOL	%M2000 - %M…
Analog Inputs / Reads	Physical AI's	INT	
	Module Status	BOOL	PCL0_d…MOD_HEALTH
	From SCADA/Field Device/CCS	WORD	%MW001 - %MW199
		REAL	%MW200 -

			%MW498
		INT	%MW500 - %MW599
	Reserved for NOR Module		%MW1000- %MW1020
	From OIT	INT	%MW1300 - %MW1499
		REAL	%MW1500 - %MW1698
Analog Outputs / Writes	Physical AO's	INT	
	Module Status	EBOOL	PCL0_d…MOD_HEALTH
	To SCADA/Field Device/CCS/OIT	WORD/REAL	%MW600 - %MW798
	To CCS/OIT	REAL	%MW800 - %MW998
Analog Inputs / Outputs	Miscellaneous if necessary for internal R/W (AO or AI)	Any	%MW2000 - %MW…

C. Program Development:

1. Safety First: It is the responsibility of the integrator to ensure that they identify and comply with the relevant safety standards. Failure to have interlock and permissive code in place may result in personal injury and damage to equipment. If you are unsure, please ask someone.
2. Functionality: Second to safety concerns, the program must follow the engineering specifications and the process control description.
3. General:

a. All control loops are to function as described in section 17051 – Computer Control System Process Control Descriptions, and as depicted on the drawings.
b. Develop the function block application in a workspace that will allow the section to be printed on standards 8.5 x 11 paper.
c. When connecting function blocks, provide straight lines that are adequately spaced apart with 90 degree turns. Limit crossing over, intersecting, or overlapping.
d. Provide a "top down" approach when writing the program functionality. Provide a logical order from the start of the sequence or process to the end.
e. Keep it simple, the majority of all logic can be accomplished using a few blocks included in EcoStruxure Control Expert.

4. Sections: Group similar programming function blocks into the same section. Multiple sections of the same type are permitted (i.e. a program may have two DI mapping sections; Discrete_Inputs01 and Discrete_Inputs02). Examples:
   a. PLC_Clock_Status
   b. Comm_HeartBeat
   c. Discrete_Inputs
   d. Descrete_Outputs
   e. Analog_Inputs
   f. Analog_Outputs
   g. Alarms
5. Standardized Sections of Logic and PLC Health:
   All PLC's, and OIT's require a heartbeat to provide a communication check. Contact the OWNER for standard logic.
   a. PLC Clock: Set the clock to the correct time using your programming computer.
      i. Plant PLCs: The City of Phoenix has code that allows the CCS to synchronize the PLC clock to the correct time at regular intervals. Request code from Lead User Technology Specialist.

ii. SCADA PLCs: Utilize the NTP utility from the NOR module.

b. Heartbeat: The City of Phoenix has code that allows the CCS to handshake with the PLC and confirm a communication connection. Request code from Lead User Technology Specialist.

c. Alarms: Request code from Lead User Technology Specialist.

6. Code Segregation: Segregate the code into as many sections as there are topics, do not group unrelated code. If you are unsure if one code snippet is related to another create a new section. This makes finding the code during commissioning, plant upgrades, and troubleshooting much easier.
7. Comments: Comments are significant, they document changes and prevent confusion. Use comment boxes to segregate code with a title and description of the purpose of the code, the more detailed the documentation the better.
8. Language: Write code using only Function Block Diagram (FBD).
9. FFBs versus DFBs: The City of Phoenix has a library of DFBs for common programming, please request the code. Using your best judgment please try to avoid the use of any other DFBs. In practice it has been found that sometimes the code inside executes, other times it does not. It is acceptable to use repetitive code however, if the repetitive code completely occupies or requires more than one section, create a DFB. If user defined function blocks are required provide each block as a single instruction in the programming environment. Designate pin assignments and names for all inputs and outputs. All inputs and outputs required for DFB logic must pass through a pin attached to that DFB, utilize these pins to connect to the PLC database. DFBs that use serial communication to non-PLC devices (i.e. generator) reference this communication internally in the DFB without pins. All DFBs shall be written in FBD language.
10. Analog Scaling: Scale all hardware analog inputs and outputs in the module configuration to engineering units (EU). All analog data to be passed to/from the Computer Control System (CCS) shall be passed in the proper data type to maintain the EU without scaling or conversion.

a. For Remote Facilities, proper data type will be WORD (with the exception of Run Times and Flow Totals). Additional scaling to add sufficient resolution will be specified by OWNER Programmer.

11. Disable Unused Analog Input/Output Channels: Disable AI/AO channels that are not used in the Module.

2.4 OIT SCREENS

A. Provide one of the following Magelis OITs to meet the requirements of the CONTRACT DOCUMENTS. Model numbers do **NOT** include conformal coating. The CONTRACTOR must add this option from the manufacturer.
   1. HMI GTO1310
   2. HMI GTO2310
   3. HMI GTO3510
   4. HMI GTO4310
   5. HMI GTO5310
   6. HMI GTO6310
   7. HMI GTO2315
   8. HMI GTO5315
   9. HMI GTO6315

B. Provide a Compact Flash card for uploading and retrieval of historical data logging from the Magelis OIT.
   1. Compact Flash Manufacturer and Part Number:
      a. Modicon, 1GB MPCYN00CF100N

C. Develop OIT screens utilizing the latest version of Vijeo Designer.

D. Panels Installed Outdoors:
   1. Mount OITs on the inside of the inner cabinet door of the control panel.

E. Animate instruments for devices utilizing a color scheme to indicate current status: The color red indicates “on”, “running”, or “open” and green indicates “off” or “closed”. Provide text with every color indicating the status of the color (i.e. if a button is red, text should overlay the button stating “On”, “Running”, or “Open”).

F. Coordinate OIT screens to resemble existing screens that are in operation with the OWNER, this includes event logging, alarming, trending, fonts, colors, and graphical buttons.

G. Provide a process flow diagram screen with graphics as described in the control description.

H. Utilize the exported database from the corresponding processor for the tag database.

2.5 NETWORKING

A. General:

1. Refer to the network drawing as shown on the CONTRACT DRAWINGS
2. Provide simplex power receptacles for network devices that requires a power source.

B. Provide all networking hardware and as indicated on the DRAWINGS.

C. Serial (RS-232, RS-422 and RS-485):

1. Provide all serial connections as stated per CONTRACT DRAWINGS.
2. Install in the control panel all necessary cables and hardware that use serial network topology (i.e. media converters, protocol converters, and properly terminated cabling).

D. Ethernet:

1. Provide all Ethernet connections as stated per CONTRACT DRAWINGS.
2. Install in the control panel all necessary cable and hardware required by the Ethernet devices.
3. All Ethernet switches must be managed switches. Provide a DIN rail mounted Cisco Managed Ethernet switch in control panels that have multiple Ethernet devices.
4. Provide protocol and media converters as needed.

E. CONTRACTOR shall turn over radio and ethernet switch to OWNER for programming. CONTRACTOR shall install radio and ethernet switch after programming is complete.

PART 3 - EXECUTION

3.1 EXAMINATION:

A. Inspect areas, surfaces, and substrates that enclose PLCs for compliance requirements, installation tolerances, and other conditions affecting performance. Adhere to compliance or tolerance requirements of the manufacturer.

3.2 APPLICATIONS:

A. Primary selection of PLCs is based upon OWNER preference followed by I/O, memory, communications, expansion, and other criteria. If multiple types of instrumentation from different vendors will communicating with the PLC, coordinate with the OWNER to insure that communication protocols are acceptable. Modbus RTU, Modbus TCP/IP, DNP3, and Hart are the only acceptable protocols.

3.3 INSTALLATION:

A. Anchor PLCs within enclosures as recommended by the PLC manufacturer.
B. Provide spacing around PLC as required by the PLC manufacturer to insure adequate cooling. Insure that the air surrounding and penetrating the PLC has been conditioned to maintain the required temperature and humidity range of the PLC.
C. Size wires entering and exiting all PLC components and modules to comply with the PLC manufacturer's requirements.
D. Blocking or obstructing ventilation slots by any means is not permitted.
E. Install all wiring so it is not obstructing the removal of modules from the backplane.
F. Provide accessibility and visibility to all PLC status lights, communication ports and memory card slots when enclosure door is open.

3.4 IDENTIFICATION:

A. Identify PLC components and wiring according to all applicable codes, standards, and contract documents sections.
B. Supply labels on each I/O module calling out each individual Input or Output name. Label spare channels as spare.

3.5 FIELD QUALITY CONTROL:

A. Field Service:
    1. Provide a qualified service representative/programmer to perform the following:

a. Inspect PLCs, wiring, components, connections, and equipment installation.
b. Assist in field testing of equipment. Test and adjust PLCs and associated programs as necessary.

3.6 RECORD DRAWINGS:

A. Maintain a set of red-line panel drawings and CONTRACT DRAWINGS to reflect changes or deviations that occur during installation, start-up, and commissioning. Incorporate these deviation into the final Operations & Maintenance manual.
B. Provide record drawing in accordance with Section 01782 – Record Documents.
C. Supply laminated 11 X 17 shop drawing in the PLC cabinet, the LCP, or ITP whichever is related to the project. This will include the final red lined drawing set from the project.

3.7 SPARE PARTS:

A. Furnish and deliver spare parts and test equipment as outlined in Section 01783 – Spare Parts and Maintenance Materials.
B. Store PLC parts according to manufacturer's requirements. Minimum storage requirements include storage indoors in a clean, dry space with uniform temperature to prevent condensation. Protect PLCs from exposure to dirt, fumes, water, corrosive substances, and physical damage. Additionally, protect PLCs from all forms of electrical and magnetic energy that could cause damage.
C. The following constitutes the minimum spare parts:
    1. I/O modules:
        a. Provide a minimum of one spare of each type of card identified.
    2. Processors:
        a. Provide a minimum of one (1) spare for each type of CPU identified.
    3. Power Supplies:
        a. Provide a minimum of one spare of each type of power supply identified.
    4. Memory:
        a. Memory Cards:
            i. If a SD memory card is installed, provide a minimum of one spare manufacture approved memory card.

b. Expandable Flash Memory Cards:
   i. If a memory extension card is installed to expand the internal memory of a processor, provide the backup processor with a memory extension card to ensure proper memory size of the backup processor.

5. Specialty Modules:
   a. Provide a minimum of one spare of each type of module identified.
6. Backplane:
   a. Provide a minimum of one (1) spare backplanes.

3.8 TESTING AND ADJUSTMENTS:

A. Perform system testing and make any adjustments necessary in accordance with this section and Section 17001 – Process Control System General Requirements.
B. Install and test all project generated programming code prior to performing the Factory Acceptance Test (FAT) and Site Acceptance Test (SAT) as stated in Section 17260 – Control Panels.

3.9 SOFTWARE DEVELOPER'S SERVICE:

A. Provide a qualified software PROGRAMMER representative to review and approve the installation of all PLCs and components.
B. Provide a qualified representative for installation supervision, start-up, and testing services. Conduct a minimum of four (4) trips to the site to approve the completed installation and to perform start-up testing of the equipment. Coordinate each visit with the ENGINEER prior to arrival on the site. Test the operation of the system in the presence of the ENGINEER and verify that the equipment conforms to the Site Acceptance Test (SAT) document. Revisit the job site as often as necessary until the installation and testing has been signed off by the OWNER or ENGINEER.
C. Provide a qualified software PROGRAMMER representative for operation and maintenance personnel training. Conduct a minimum of two (2) trips to the site to perform the services as described under Section 01821 – Instruction of Operations

and maintenance Personnel. Coordinate each visit with the ENGINEER prior to arrival on the site.

D. All costs, including travel, lodging, meals, and incidentals for the CONTRACTOR and PROGRAMMER, are considered included in the CONTRACT price.

END OF SECTION