

**CITY OF AUSTIN
PUBLIC WORKS DEPARTMENT**



**PROJECT MANUAL
Bid Set**

VOLUME 2 of 3

**South Austin Regional WWTP
Thickener Improvements Project**

**C.I.P. PROJECT NUMBER: 3333.016
I.F.B. PROJECT NUMBER: 6100 CLMC558**

CITY OF AUSTIN
Public Works Department
PO Box 1088
Austin, TX 78767

Documents Prepared By:
CDM Smith Inc.
TBPE Firm Registration No. F-3043
12357-A Riata Trace Pkwy Ste. 210
Austin, Texas 78727

July 25, 2016

It is the policy of the City of Austin to involve certified Minority Owned Business Enterprises (MBEs) and Women Owned Business Enterprises (WBEs) in City Contracting. MBE and WBE goals for this solicitation are contained in Volume 3, MWBE Participation for Construction Projects.



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SECTION 02140
DEWATERING AND DRAINAGE

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. Design, furnish, install, operate, monitor, maintain and remove a temporary dewatering system as required to lower and control water levels at least 3-ft below subgrades of excavations and to permit construction to proceed in-the-dry.
- B. Furnish, maintain and remove temporary surface water control measures adequate to drain and remove surface water entering excavations.
- C. Retain the services of a professional engineer registered in the State in which the work will occur to prepare dewatering and drainage system designs and submittals described herein.
- D. Work shall include the design, equipment, materials, installation, protection, and monitoring of geotechnical instrumentation required to monitor the performance of the dewatering and drainage system as required herein.
- E. Collect and properly dispose of all discharge water from the dewatering and drainage systems in accordance with the provisions of Section 01500. Under no circumstances shall water from dewatering systems be discharged into the existing or new sanitary sewer systems.
- F. Obtain and pay for all permits required for dewatering and drainage systems.
- G. Repair damage caused by dewatering and drainage system operations.

1.02 RELATED WORK

- A. Submittals are included in Section 01300.
- B. Subgrade Preparation is included in Section 201S. Structural Excavation and Backfill is included in Section 401S.
- C. Excavation Safety Systems are included in Section 509S.
- D. Pipe is included in Section 510.
- E. Salvaging and Placing Topsoil is included in Section 601S.
- F. Earthwork is included in Section 02200.
- G. Erosion and Sedimentation Control is included in Section 02270.

1.03 SUBMITTALS

- A. Dewatering and drainage system designs shall be prepared by a licensed professional engineer retained by the Contractor. The Contractor shall submit a copy of the licensed professional engineer's certification on the PE form specified in Section 01300. The Contractor shall also submit qualifications as required herein.

- B. The Contractor shall submit a dewatering and drainage system design plan. The plan shall include a description of the proposed dewatering system and include the proposed installation methods to be used for dewatering and drainage system elements. The plan shall include equipment, drilling methods, holes sizes, filter sand placement techniques, sealing materials, development techniques, the number and location of dewatering points and observations wells, etc. Include the dewatering system design calculations in the plan.
- C. The plan shall identify the anticipated area influenced by the dewatering system and address impacts to adjacent existing and proposed structures.
- D. Coordinate dewatering and drainage submittals with the excavation and support of excavation submittals. The submittal shall show the areas and depths of excavation to be dewatered.
- E. Do not proceed with any excavation or dewatering activities until the dewatering submittals has been reviewed by the Engineer.

1.04 QUALITY ASSURANCE

- A. Regulations: Perform all work in accordance with current applicable regulations and codes of all Federal, State and local agencies.
- B. The Contractor shall have at least 5 years of experience with work compatible to the Work shown and specified, employing labor and supervisory personnel who are similarly experienced in this type of Work.
- C. The Contractor's design engineer shall be registered in the State in which the work is located and have a minimum of 5 years of professional experience in the design and construction of dewatering and drainage systems and shall have completed not less than 5 successful dewatering and drainage projects of equal type, size, and complexity to that require for the work.

1.05 DESIGN REQUIREMENTS

- A. The Contractor is responsible for the proper design and implementation of methods for controlling surface water and groundwater.
- B. The primary purpose of the groundwater control system is to preserve the natural undisturbed condition of the subgrade soils in the areas of the proposed excavations. Prior to excavation, the Contractor shall lower the groundwater to at least 3-ft below the lowest excavation subgrade elevation. Additional groundwater lowering may be necessary beyond the 3-ft requirement, depending on construction methods and equipment used and the prevailing groundwater and soil conditions. The Contractor is responsible for lowering the groundwater as necessary to complete construction in accordance with the plans and specifications at no additional cost to the Owner.
- C. Design deep wells, well points and sumps, and all other groundwater control system components to prevent loss of fines from surrounding soils. Sand filters shall be used with all dewatering installations unless screens are properly sized by the Contractor's design engineer to prevent passage of fines from surrounding soils.

- D. The Contractor shall be responsible for damage to properties, buildings or structures, sewers and other utility installations, pavements and work that may result from dewatering or surface water control operations.
- E. Design review and field monitoring activities by the Owner or by the Engineer shall not relieve the Contractor of his/her responsibilities for the work.

1.06 DEFINITIONS

- A. Where the phrase "in-the-dry" is used in this Section, it shall be defined as an excavation subgrade where the groundwater level has been lowered to at least 3-ft below the lowest level of the excavation, is stable with no ponded water, mud, or muck, is able to support construction equipment without rutting or disturbance and is suitable for the placement and compaction of fill material, pipe or concrete foundations.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Piping, pumping equipment and all other materials required to provide control of surface water and groundwater in excavations shall be suitable for the intended purpose.
- B. Standby pumping systems and a source of standby power shall be maintained at all sites.

PART 3 EXECUTION

3.01 GENERAL

- A. Control surface water and groundwater such that excavation to final grade is made in-the-dry, the natural undisturbed condition of the subgrade soils are maintained, and softening and/or instability or disturbance due to the presence or seepage of water does not occur. All construction and backfilling shall proceed in-the-dry and flotation of completed portions of work shall be prohibited.
- B. Methods of groundwater control may include but are not limited to perimeter trenches and sump pumping, perimeter groundwater cutoff, well points, ejectors, deep wells and combinations thereof.
- C. Where groundwater levels are above the proposed bottom of excavation level, a pumped dewatering system will be required for predrainage of the soils prior to excavation, and for maintaining the lowered groundwater level until construction has been completed to such an extent that the structure, pipeline or fill will not be floated or otherwise damaged.
- D. It is expected that the type of system, spacing of dewatering units and other details of the work will have to be varied depending on soil/water conditions at a particular location.
- E. All work included in this Section shall be done in a manner which will protect adjacent structures and utilities and shall not cause loss of ground or disturbance to the pipe bearing soils or to soils which support overlying or adjacent structures.

- F. Locate groundwater control system components where they will not interfere with construction activities adjacent to the work area or interfere with the installation and monitoring of geotechnical instrumentation. Excavations for sumps or drainage ditches shall not be made within or below 1H:1V slopes extending downward and out from the edges of existing or proposed foundation elements or from the downward vertical footprint of the pipe.

3.02 SURFACE WATER CONTROL

- A. Construct surface water control measures, including dikes, ditches, sumps and other methods to prevent, as necessary, flow of surface water into excavations and to allow construction to proceed without delay.

3.03 EXCAVATION DEWATERING

- A. At all times during construction, provide and maintain proper equipment and facilities to promptly remove and properly dispose of all water entering excavations. Excavations shall be maintained in-the-dry. Groundwater levels shall be kept at least 3-ft below the lowest excavation level.
- B. Excavation dewatering shall maintain the subgrade in a natural undisturbed condition and until the fill, structure or pipes to be built thereon have been completed to such extent that they will not be floated or otherwise damaged by allowing water levels to return to natural elevations.
- C. Pipe, masonry, and concrete shall not be placed in water or be submerged within 24 hours after being installed. Water shall not flow over new masonry or concrete within four days after placement.
- D. In no event shall water rise to cause unbalanced pressure on structures until the concrete or mortar has set at least 24 hours. Prevent flotation of pipe by promptly placing backfill.
- E. Dewatering shall at all times be conducted in such a manner as to preserve the natural undisturbed condition of the subgrade soils at the proposed bottom of excavation.
- F. If the subgrade of the trench or excavation bottom becomes disturbed due to inadequate dewatering or drainage, excavate below normal grade as directed by the Engineer and refill with structural fill, screened gravel or other material as approved by the Engineer at the Contractor's expense.
- G. It is expected that the initial dewatering plan may have to be modified to suit the variable soil/water conditions to be encountered during construction. Dewater and excavate, at all times, in a manner which does not cause loss of ground or disturbance to the pipe bearing soil or soil which supports overlying or adjacent structures.
- H. If the method of dewatering does not properly dewater the excavation as specified, install groundwater observation wells as directed by the Engineer and do not place any pipe or structure until the readings obtained from the observation wells indicate that the groundwater has been lowered a minimum of 3-ft below the bottom of the final excavation within the excavation limits.

- I. Dewatering units used in the work shall be surrounded by suitable filter sand and no fines shall be removed by pumping. Pumping from the dewatering system shall be continuous until pipe or structure is adequately backfilled. Stand-by pumps shall be provided.
- J. Water entering the excavation from precipitation or surface runoff shall be collected in shallow ditches around the perimeter of the excavation, drained to a sump and pumped from the excavation to maintain a bottom free from standing water.
- K. Drainage shall be disposed of in an approved area as specified in Section 01500. Existing or new sanitary sewers shall not be used to dispose of drainage.

3.04 REMOVAL OF SYSTEMS

- A. Dewatering should continue until the construction has been completed, and the dewatering system should be turned off in stages to allow groundwater to recover to its original level gradually, over a period of 3 to 5 days.
- B. At the completion of the excavation and backfilling work, and when approved by the Engineer, all pipe, deep wells, wellpoints, pumps, generators, observation wells, other equipment and accessories used for the groundwater and surface water control systems shall be removed from the site. All materials and equipment shall become the property of the Contractor. All areas disturbed by the installation and removal of groundwater control systems and observation wells shall be restored to their original condition.
- C. Leave in place any casings for deep wells, wellpoints or observation wells located within the plan limits of structures or pipelines or within the zone below 1H:1V planes extending downward and out from the edges of foundation elements or from the downward vertical footprint of the pipe, or where removal would otherwise result in ground movements causing adverse settlement to adjacent ground surface, utilities or existing structures.
- D. Where casings are pulled, holes shall be filled with sand. Where left in place, casings should be filled with cement grout and cut off a minimum of 3-ft below finished ground level or 1-ft below foundation level so as not to interfere with finished structures or pipelines.
- E. When directed by the Engineer, observation wells should be left in place for continued monitoring. When so directed, cut casings flush with final ground level and provide protective lockable boxes with locking devices. The protective boxes shall be suitable for the traffic and for any other conditions to which the observation wells will be exposed.

END OF SECTION

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SECTION 02200
EARTHWORK

PART 1 GENERAL

1.01 STATUTORY REQUIREMENTS

- A. All excavation, trenching, sheeting, bracing, etc., shall comply with the requirements of OSHA excavation safety standards (29 CFR Part 1926.650 Subpart P). Where conflict between OSHA, State, and local regulations exists, the most stringent requirements shall apply.

1.02 SCOPE OF WORK

- A. Furnish all labor, materials and equipment and incidentals necessary to perform all grading; place and fill; and dispose of unsuitable, waste, and surplus materials as shown on the Drawings and as specified herein.
- B. Provide the services of a Professional Engineer registered in the State of Texas to prepare temporary excavation support system designs and submittals, as specified in these specifications.
- C. Furnish and install temporary excavation support systems, including sheeting, shoring and bracing to ensure the safety of personnel and protect adjacent structures, piping, etc., in accordance with Federal, State and local laws, regulations and requirements.

1.03 RELATED WORK

- A. Excavation is included in Section 111S.
- B. Subgrade Excavation is included in Section 201S.
- C. Structural Excavation and Backfill is included in Section 401S.
- D. Excavation Safety Systems are included in Section 509S.
- E. Pipe is included in Section 510.
- F. Salvaging and Placing Topsoil is included in Section 601S.
- G. Grades, Lines & Levels are included in Section 01050.
- H. Construction and Demolition Waste Management is included in Section 01505.
- I. Dewatering and Drainage are included in Section 02140.
- J. Erosion and Sedimentation Control is included in Section 02270.

1.04 SUBMITTALS

- A. Submit design data, test reports, qualifications, and safety plan as specified in Section 401S Structural Excavation and Backfill, Section 509S Excavation Safety Systems, and Section 510 Pipe.
- B. Safety Plan
 - 1. Prior to beginning excavation work, submit an Excavation Safety Plan in accordance with Section 509S. This plan shall be sealed by the excavation support system design engineer that meets specified qualifications. Work shall not begin until the plan has been submitted to the Engineer.

1.05 REFERENCE STANDARDS

- A. American Society for Testing and Materials (ASTM)
 - 1. ASTM D1557 – Standard Test Methods for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures.
 - 2. ASTM D698 – Test Method for Laboratory Compaction Characteristics of Soil Using Standard Efforts.
- B. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.06 QUALITY ASSURANCE

- A. At all structures, prior to the placement of bedding material, concrete work mats, structural fill or structural concrete, coordinate with the soils testing laboratory to verify the suitability of the existing subgrade soil and to perform in-place soil density tests as required to verify that the bearing capacity of the sub grade is sufficient.
- B. Prior to and during the placement of backfill and fill, coordinate with the soils testing laboratory to perform in-place soil density tests to verify that the backfill/fill material has been compacted in accordance with the compaction requirements specified elsewhere. The Engineer may designate areas to be tested.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 PREPARATION

- A. Test Pits
 - 1. Perform exploratory excavation work (test pits) for the purpose of verifying the location of underground utilities and structures and to check for unknown utilities and structures, prior to commencing excavation work.

2. Test pits shall be backfilled as soon as the desired information has been obtained. Backfilled surfaces shall be stabilized in accordance with approved erosion and sedimentation control plans.

B. Dewatering and Drainage Systems

1. Temporary dewatering and drainage systems, as specified in Section 02140, shall be in place and operational prior to beginning excavation work.

3.02 GENERAL FILLING AND BACKFILLING

- A. Filling and backfilling procedures shall be in accordance with Section 401S Structural Excavation and Backfill, Section 509S Excavation Safety Systems, and Section 510 Pipe.

3.03 COMPACTION REQUIREMENTS

- A. Compaction requirements shall be as required by Section 401S Structural Excavation and Backfill and Section 510 Pipe.

3.04 MANAGEMENT OF UNSUITABLE, WASTE, AND/OR SURPLUS EXCAVATED MATERIAL

- A. Unsuitable and surplus excavated material shall be managed as specified in Section 01505 Construction and Demolition Waste Management.

3.05 GRADING

- A. Grading shall be performed as required to match existing grading.
- B. Grading shall be performed in accordance with Section 01050 Grades, Lines & Levels.

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SECTION 02270
EROSION AND SEDIMENTATION CONTROL

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. Furnish all labor, materials, equipment and incidentals required and perform all installation, maintenance, removal and area cleanup related to erosion and sedimentation control work as shown on the Drawings and as specified herein. The work shall include, but not necessarily be limited to; installation of temporary access ways and staging areas, silt fences, stone filter boxes, stone filter berms, sediment removal and disposal, device maintenance, removal of temporary devices, temporary mulching, excelsior matting installation and final cleanup.

1.02 RELATED WORK

- A. Seeding for Erosion Control is included in Section 604S.
- B. Rock Berm is included in Section 639S.
- C. Stabilized Construction Entrance is included in Section 641S.
- D. Silt Fence is included in Section 642S.
- E. Mulch Sock is included in Section 648S.
- F. Earthwork is included in Section 02200.

1.03 SUBMITTALS

- A. Submit, in accordance with Section 01300, within 10 days after award of Contract, technical product literature for all commercial products, including straw mulch tackifier, to be used for erosion and sedimentation control.

1.04 QUALITY ASSURANCE

- A. Be responsible for the timely installation and maintenance of all sedimentation control devices necessary to prevent the movement of sediment from the construction site to offsite areas or into the stream system via surface runoff or underground drainage systems. Measures in addition to those shown on the Drawings necessary to prevent the movement of sediment off site shall be installed, maintained, removed, and cleaned up at the expense of the Contractor. No additional charges to the Owner will be considered.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Rock berms shall meet the requirements specified in Section 639S and as shown on the Drawings.
- B. Stabilized construction entrances shall meet the requirements specified in Section 641S and as shown on the Drawings.

- C. Silt fences shall meet the requirements specified in Section 642S and as shown on the Drawings.
- D. Mulch socks shall meet the requirements specified in Section 648S and as shown on the Drawings.
- E. Straw mulch shall be comprised of threshed straw of oats, wheat, barley, or rye that is free from noxious weeds, mold or other objectionable material. The straw mulch shall contain at least 50 percent by weight of material to be 10-in or longer. Straw shall be in an air-dry condition and suitable for placement with blower equipment.
- F. Latex acrylic copolymer or organic tackifier shall be a commercial product specifically manufactured for use as straw mulch tackifier.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Silt Fence Installation
 - 1. Silt fences shall be installed as necessary to prevent off site movement of sediment produced by construction activities as directed by the Engineer. Silt fences shall be installed in accordance with Section 642S.
 - 2. Install pre-fabricated silt fence according to manufacturer's instructions.
- B. Staging areas and access ways shall be surfaced with a minimum depth of 4-in of crushed stone.

3.02 MAINTENANCE AND INSPECTIONS

- A. Inspections
 - 1. Contractor shall make a visual inspection of all erosion and sedimentation control devices once per week and promptly after every rainstorm. If such inspection reveals that additional measures are needed to prevent movement of sediment to offsite areas, Contractor shall promptly install additional devices as needed. Sediment controls in need of maintenance shall be repaired promptly.
- B. Device Maintenance
 - 1. Silt Fences
 - a. Remove accumulated sediment once it builds up to 6 inches, as indicated in the Drawings.
 - b. Replace any damaged fabric.
 - c. Make other repairs as necessary to ensure that the fence is filtering all runoff directed to the fence.
 - 2. Add crushed stone to access ways and staging area as necessary to maintain a firm surface free of ruts and mud holes.

3.03 TEMPORARY MULCHING

- A. Apply temporary mulch to areas where rough grading has been completed but final grading is not anticipated to begin within 30 days of the completion of rough grading.

3.04 REMOVAL AND FINAL CLEANUP

- A. Once the site has been fully stabilized against erosion, remove sediment control devices and all accumulated silt. Dispose of silt and waste materials in an approved location and in proper manner that will not contribute to additional siltation. Regrade all areas disturbed during this process and stabilize against erosion with surfacing materials as indicated on the Drawings.

END OF SECTION

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SECTION 02623
BURIED POLYVINYL CHLORIDE (PVC) PRESSURE PIPE

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. Furnish all labor, materials, equipment and incidentals required and install and test thickener scum and non-potable water polyvinyl chloride (PVC) pipe, complete as shown on the Drawings and as specified herein.
- B. Pipe or piping refers to all pipe, fittings, material and appurtenances required to construct PVC non-potable water pipe complete, in place.
- C. Buried PVC chemical piping shall be installed in trench as described herein. Joints and testing for buried PVC chemical piping shall be in accordance with Section 15064.

1.02 RELATED WORK

- A. Excavation Safety Systems are included in Section 509S.
- B. Pipe is included in Section 510.
- C. Buried Water Valves is included in Section 511S.
- D. Salvaging and Placing Topsoil is included in Section 601S.
- E. Testing of Pipelines is included in Section 01666.
- F. Cleaning and Slip-lining of Existing Pipe is included in Section 02624.
- G. Plastic Pipe and Fittings are included in Section 15064.

1.03 SUBMITTALS

- A. Submit, in accordance with Section 01300, and within 30 days of the Effective Date of the Agreement, the name of the pipe and fitting manufacturers and a list of materials to be furnished by each manufacturer. Also, include information on local representative for each manufacturer, if product is sold through a distributor.
- B. Shop Drawings including piping layouts and schedules shall include dimensioning, fittings, types and locations of valves and appurtenances, joint details, methods and location of supports, anchorage, gasket material, grade of material and all other pertinent technical information for all items to be furnished.
- C. Prior to each shipment of pipe, certified test reports that the pipe for this Contract was manufactured and tested in accordance with the ASTM and AWWA Standards specified herein shall be submitted.

1.04 REFERENCE STANDARDS

- A. ASTM International

1. ASTM D1784 - Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
2. ASTM D2241 - Standard Specification for Poly (Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series).
3. ASTM D3139 - Standard Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals.
4. ASTM F477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.

B. American Water Works Association (AWWA)

1. AWWA C110 - Ductile-Iron and Gray-Iron Fittings, 3-in Through 48-in (75mm Through 1219mm) for Water.
2. AWWA C111 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
3. AWWA C600 - Installation of Ductile-Iron Water Mains and Their Appurtenances.
4. AWWA C-605 – Underground Installation of Polyvinyl Chloride (PVC) Pressure Pipe and Fittings for Water.
5. AWWA C651 - Disinfecting Water Mains.
6. AWWA C900 - Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4-in through 12-in for Water Distribution.
7. AWWA C905 - Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings 14-in through 48-in for Water Transmission and Distribution.
8. AWWA M-23 – Manual of Water Supply Practices PVC Pipe, Design and Installation.

C. National Sanitation Foundation (NSF)

1. Standard No. 14 - Plastic Piping Components and Related Materials.
2. Standard No. 61 - Drinking Water System Components - Health Effects.

D. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

- A. All PVC non-potable water pipe shall be from a single manufacturer. The supplier shall be responsible for the provisions of all test requirements specified in ASTM D3034 and NSF Standards as applicable. In addition, all PVC pipe to be installed under this Contract may be inspected at the plant for compliance with this Section by an independent testing laboratory provided by the Owner at the Owner's expense.

- B. Inspections of the pipe may also be made by the Engineer or other representatives of the Owner after delivery. The pipe shall be subject to rejection at any time on account of failure to meet any of the requirements specified herein, even though sample pipes may have been accepted as satisfactory at the place of manufacture. Pipe rejected after delivery shall be marked for identification and shall be removed from the job at once.

1.06 SYSTEM DESCRIPTION

- A. The equipment and materials specified herein are intended to be of standard types for use in transporting non-potable water and other pumped fluids as designated in the Drawings.
- B. Contractor is responsible for compatibility between pipe materials, fittings and appurtenances.
- C. Buried plastic piping systems shall be designed for the following conditions:
 - 1. System: Thickener Scum (TSC)
 - a. Material: Schedule 80 PVC
 - b. Fluids: Water
 - c. Pressure: Atmosphere to 20 psig
 - d. Temperature: Ambient
 - 2. System: Non-potable Water (NPW)
 - a. Material: Schedule 80 PVC
 - b. Fluids: Water
 - c. Pressure: Atmosphere to 90 psig
 - d. Temperature: Ambient

1.07 DELIVERY, STORAGE AND HANDLING

- A. All items shall be bundled or packaged in such a manner as to provide adequate protection of the ends during transportation to the site. Any pipe damaged in shipment shall be replaced as directed by the Engineer.
- B. PVC items deteriorate in sunlight and are slightly brittle, especially at lower temperatures, so care shall be taken in loading, transporting and unloading items to prevent injury to the items. All items shall be examined before installation and no piece shall be installed which is found to be defective. Handling and installation of pipe and fittings shall be in accordance with the manufacturer's instructions, referenced standards and as specified herein.
- C. 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.
- D. Any gouges or scratches that extend 10 percent or more into the pipe wall shall be cause for rejection of that pipe. The undamaged portion may cut off and used. Rejected materials shall be clearly marked as rejected, segregated and removed from the site.
- E. While stored, pipe shall be adequately supported from below at not more than 3-ft intervals to prevent deformation. The pipe shall be stored in stacks no higher than that given in the following table:

| Pipe Diameter (inches) | Max. No. of Rows Stacked |
|------------------------|--------------------------|
| 8 or less | 5 |
| 12 to 21 | 4 |
| 24 to 30 | 3 |
| 33 to 48 | 2 |

- F. Pipe and fittings shall be stored in a manner which will keep them at ambient outdoor temperatures and out of the sunlight or delivered to the site so that no pipe is exposed to sunlight for more than 60 days. Temporary shading as required to meet this requirement shall be provided. Simple covering of the pipe and fittings which allows temperature buildup or direct or indirect sunlight will not be permitted.
- G. If any defective item is discovered after it has been installed, it shall be removed and replaced with an exact replacement item in a satisfactory manner by the Contractor, at the Contractor's own expense. All pipe and fittings shall be thoroughly cleaned before installation and the interior shall be kept clean until testing.
- H. In handling the items, use special devices and methods as required to achieve the results specified herein. No uncushioned devices shall be used in handling the item.

PART 2 PRODUCTS

2.01 POLYVINYL CHLORIDE (PVC) PIPE AND FITTINGS

- A. Pipe shall be manufactured from PVC compounds meeting ASTM D1784, Class 12454-B in accordance with ASTM D1785, PVC 1120. The pipe shall have a minimum hydrostatic design stress of 2,000 psi at 73 degrees F and shall be suitable for field cutting and solvent welding. Pipe shall be of the sizes as shown on the Drawings and shall be Schedule 80 unless otherwise specified in this Section.
- B. Fittings shall be the socket type for solvent welded joints conforming to ASTM D2467 or ASTM D2466 where Schedule 40 pipe is shown on the Drawings. Fittings shall be manufactured from PVC compound meeting ASTM D1784, Class 12454-B. Solvent cement shall be as specified in ASTM D2564.

2.02 TRACER TAPE

- A. Inductive Tracer Detective Tape shall be placed directly above the centerline of all non-metallic pipe a minimum of 12 inches below subgrade or, in areas outside the limits of pavement, a minimum of 18 inches below finished grade. The tracer tape shall be encased in a protective, inert, plastic jacket and color coded according to American Public Works Association Uniform Color Code. Except for minimum depth of cover, the tracer tape shall be placed according to manufacturer's recommendations. Manufacturers must be listed on City of Austin SPL No. WW-597.

PART 3 EXECUTION

3.01 INSTALLATION OF PVC PIPE AND FITTINGS

- A. No single piece of pipe shall be laid unless it is straight. The centerline of the pipe shall not deviate from a straight line drawn between the centers of the openings at the ends of the pipe by more than 1/16-in per foot of length. If a piece of pipe fails to meet this requirement, check for straightness, it shall be rejected and removed from the site. Laying instructions of the manufacturer shall be explicitly followed.
- B. If any defective pipe is discovered after it has been installed, it shall be removed and replaced with a sound pipe in a satisfactory manner at no additional cost to the Owner. All pipe and fittings shall be thoroughly cleaned before installation, shall be kept clean until they are used in the work and when laid, shall conform to the lines and grades required. PVC pipe and fittings shall be installed in accordance with requirements of the manufacturer, ASTM D2321 and AWWA C605 or as otherwise provided herein.
- C. As soon as the excavation is complete to normal grade of the bottom of the trench, bedding shall be placed, compacted and graded to provide firm, uniform and continuous support for the pipe. Bell holes shall be excavated so that only the barrel of the pipe bears upon the bedding. The pipe shall be laid accurately to the lines and grades indicated on the Drawings. Blocking under the pipe will not be permitted. Bedding shall be placed evenly on each side of the pipe to mid-diameter and hand tools shall be used to force the bedding under the haunches of the pipe and into the bell holes to give firm continuous support for the pipe. Bedding shall then be placed to 12-in above the top of the pipe. The initial 3-ft of backfill above the bedding shall be placed in 1-ft layers and carefully compacted. Generally, the compaction shall be done evenly on each side of the pipe and compaction equipment shall not be operated directly over the pipe until sufficient backfill has been placed to ensure that such compaction equipment will not have a damaging effect on the pipe. Equipment used in compacting the initial 3-ft of backfill shall be approved by the pipe manufacturer's representative prior to use.
- D. All piping shall be sound and clean before installation. When installation is not in progress, including lunchtime, the open ends of the pipe shall be closed by watertight plug or other approved means. Good alignment shall be preserved during installation. The deflection at joints shall not exceed that recommended by manufacturer. Fittings, in addition to those shown on the Drawings, shall be provided, if required, in crossing utilities that may be encountered upon opening the trench.
- E. When cutting pipe is required, the cutting shall be done by machine, leaving a smooth cut at right angles to the axis of the pipe. Cut ends of pipe to be used with a bell shall be beveled to conform to the manufactured spigot end and a reference mark made at the same distance from the pipe end as measured from a factory marked end from the same manufacturer.
- F. The Engineer may examine each bell and spigot end to determine whether any preformed joint has been damaged prior to installation. Any pipe having defective joint surfaces shall be rejected, marked as such and immediately removed from the job site.
- G. Each length of the pipe shall have the assembly mark aligned with the pipe previously laid and held securely until enough backfill has been placed to hold the pipe in place. Joints shall not be "pulled" or "cramped".

- H. Before any joint is made, the pipe shall be checked to assure that a close joint with the next adjoining pipe has been maintained and that the inverts are matched and conform to the required grade. The pipe shall not be driven down to grade by striking it.
- I. Precautions shall be taken to prevent flotation of the pipe in the trench.
- J. When moveable trench bracing such as trench boxes, moveable sheeting, shoring or plates are used to support the sides of the trench, care shall be taken in placing and moving the boxes or supporting bracing to prevent movement of the pipe, or disturbance of the pipe bedding and the backfill. If trench boxes, moveable sheeting, shoring or plates have been installed below the top of pipe, they shall be moved slowly taking care not to disturb pipe, bedding or backfill. As trench boxes, moveable sheeting, shoring or plates are moved, pipe bedding shall be placed to fill any voids created and the backfill shall be recomacted to provide uniform side support for the pipe.
- K. Restrained joints shall be installed where shown on the Drawings.

3.02 JOINTING PVC PIPE (SOLVENT CEMENTED)

- A. Joints shall be solvent cemented unless flanged or threaded are otherwise shown on the Drawings or are specified as other types herein. In making solvent cemented connections, clean dirt and moisture from pipe and fittings, bevel pipe ends slightly with emery cloth to remove any shoulder or burrs created by cutting of the pipe. Solvent cement joints shall be made in accordance with ASTM D2855 except that solvent cement formulated especially for and as specified above shall be used for joining CPVC pipe and fittings. Primer shall be used whenever recommended by the pipe, fitting, or cement manufacturer and in all cases for joints on pipe systems 4-in in diameter or larger. Making solvent cement joints shall not be performed and the work shall stop when the temperature, measured in the shade, is 40 degrees F and falling.

3.03 JOINTING MECHANICAL JOINT FITTINGS

- A. For potable water pipe, mechanical joints at valves, fittings and where designated shall be in accordance with the AWWA C111 and the instructions of the manufacturer.
- B. PVC sewer pipe and fittings shall be jointed in accordance with the recommendations of the latest ASTM Standards and detailed instructions of the manufacturer. Suitable PVC to cast iron adaptors shall be installed prior to installing fittings.
- C. PVC beveled spigot shall be cut flush prior to insertion in mechanical joint pipe. To assemble the joints in the field, thoroughly clean the joint surfaces and rubber gasket with soapy water before tightening the bolts. Bolts shall be tight to the specified torques. Under no condition shall extension wrenches or pipe over handle of ordinary ratchet wrench be used to secure greater leverage.

3.04 FILLING AND TESTING

- A. After installation, the pipe shall be tested for compliance as specified herein. Furnish all necessary equipment and labor for the hydrostatic pressure test on the pipelines.
- B. Submit detailed test procedures and method for Engineer's review. In general, testing shall be conducted in accordance with AWWA C605. The method and procedures for performing the

hydrostatic pressure test shall be approved by the Engineer. Submit the plan for testing to the Engineer at least 10 days before starting a test.

- C. Pressure pipelines shall be subjected to a hydrostatic pressure of 1.25 times the working pressure at the highest point along the test segment. This test pressure shall be maintained for a minimum of 2 hours. The hydrostatic testing allowances shall not exceed those indicated in AWWA C605. Provide suitable restrained bulkheads as required to complete the hydrostatic testing specified.
- D. Contractor shall make any taps and furnish all necessary caps, plugs etc., as may be required in conjunction with performing the testing.
- E. Gravity pipelines shall be subjected to hydrostatic pressure test as specified in AWWA C605.
- F. All valves and valve boxes shall be properly located and installed and operable prior to testing. Bulkheads shall be provided with a sufficient number of outlets for filling and draining the line and for venting air.
- G. Hydrostatic pressure tests shall conform to Section 7.3 of AWWA C605. Furnish gauges, meters, pressure pumps and other equipment needed to fill the line slowly and perform the required hydrostatic pressure tests.
- H. The Owner will provide a source of supply from the existing treated water distribution system for Contractor's use in filling the lines. An air break shall be maintained at all times between the Owner's distribution system and the Contractor's equipment to prevent cross-connection. The line shall be slowly filled with water and the specified test pressure shall be maintained in the pipe for the entire test period by means of a pump furnished by the Contractor. Provide accurate means for measuring the quantity of makeup water required to maintain this pressure.
- I. Duration of pressure test shall not be less than 2 hours. All leaks evident at the surface shall be repaired and leakage eliminated regardless of the total leakage as shown by test. Lines which fail to meet tests shall be repaired and retested as necessary until test requirements are complied with. Defective materials, pipes, valves and accessories shall be removed and replaced.

3.05 FLUSHING AND CHLORINATION OF PIPELINES

- A. Before being placed in service and prior to hydrostatic testing, all new water pipelines shall be chlorinated in accordance with AWWA C651. The procedure shall be approved by the Engineer in advance.
- B. The location of the chlorination and sampling points will be determined by the Engineer in the field. Taps for chlorination and sampling shall be installed by the Contractor. Uncover and backfill the taps as required.
- C. The general procedure for chlorination shall be first to flush all dirty or discolored water from the pipeline. The flushing velocity shall be a minimum of 3 ft/sec and continue until at least three changes of water have passed through the segment being flushed. Flushing operations shall be conducted without causing erosion, damage, nuisance or interruption of traffic and comply with all regulatory requirements. Then introduce chlorine in approved dosages through a tap at one end, while water is being withdrawn at the other end of the line. The concentration

and residence time of the chlorine solution in the pipeline will depend on the type of disinfection method used, as described in AWWA 651.

- D. Following the chlorination period, all treated water shall be flushed from the lines at their extremities and replaced with water from the distribution system. All treated water flushed from the lines shall be disposed by discharging to the nearest sanitary sewer or other approved means. No discharge to any storm sewer or natural water courses will be allowed. Bacteriological sampling and analysis of the replacement water may then be made by the Engineer in full accordance with AWWA C651. Rechlorination will be required, if necessary and the line shall not be placed in service until the requirements of the State Public Health Department are met.
- E. Special disinfecting procedures shall be used in connections to existing mains and where the method outlined above is not practical.

END OF SECTION

SECTION 02624
CLEANING AND SLIP-LINING OF EXISTING PIPE

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. This Section presents requirements for the high pressure cleaning of existing pipelines and the installation and testing of pipelines by slip-lining. As shown on the Drawings, the Contractor shall install proposed 4-inch TSC lines either by slip-lining pipes in existing 8-inch TSC lines or by replacing existing 8-inch TSC lines in place. The Contractor shall use this specification to govern the slip-lining method, if used.
- B. Furnish all labor, materials, installation equipment, water cleaning (power-wash) equipment, backflow prevention devices, and incidentals required to install all pipe by slip-lining as shown on the Drawings.
 - 1. Water required for pipeline cleaning purposes will be available from the Owner's water system, or from the treatment plant's non-potable process water system. Potable water used from the Owner's water system will be metered and paid for by the Contractor at already existing water usage fees. If the Contractor desires to use the non-potable process water, the Contractor shall provide the tools, manpower, equipment, hoses, piping, and supplies necessary to make connection with the process water system. The desired point of connection to the process water system shall be approved by the Owner and Engineer.
- C. Piping shall be located substantially as shown on the Drawings. Pipe fitting notation is for the Contractor's convenience and does not relieve him/her from installing and jointing different or additional items were required to achieve a complete piping system.
- D. Unless otherwise noted, "pipe" shall mean pipe work of any type including pipe, fittings, joints, or appurtenances.

1.02 RELATED WORK

- A. Excavation Safety Systems are included in Section 509S.
- B. Pipe is included in Section 510.
- C. Salvaging and Placing Topsoil is included in Section 601S.
- D. Summary of Work is in Section 01010.
- E. Testing of Pipelines is included in Section 01666.
- F. Buried Polyvinyl Chloride Pressure Pipe is included in Section 02623.

1.03 SUBMITTALS

- A. All submittals shall be in accordance with Section 01300 and additional requirements of this section.

- B. Pre-Construction Submittals: At least 30 days before the mobilization of equipment or purchase of materials for work specified in this Section, the Contractor shall submit the following:
1. A pipe-cleaning plan, including time schedule and written procedure. Submit the methods for power-wash cleaning of existing 8-inch TSC pipelines. The plan shall include the equipment to be used; the segments of the system to be cleaned at a given time; the calculated volume of pipe to be cleaned, by segment; and the approximate volume of water to be introduced into the system at the end of each branch line, by segment. Submit a plan for spills, cleanup, and disposal of cleaning process water stream and debris.
 2. A pipe-laying schedule indicating station location of all significant pipeline items for proposed 4-inch TSC lines, including fittings, bends, valves, entry pits, pulling pits, etc.
 3. Descriptions, shop drawings describing and illustrating methods and equipment proposed for installation of the pipe by slip-lining within the existing pipeline. The submittal shall address, as a minimum: work task schedule, delivery of the pipe to the site, pipe installation method, pipe insertion geometry, distance between insertion/pull pits, pipe joining, excavation of pits, size of insertion/pull pits, protection of pipe during insertion, and pipe testing and disinfection.
 4. Pipe material submittals as specified. Contractor shall submit calculations for pipe stress during slip-line installation by pushing or pulling, and any insertion bending. Calculations shall demonstrate the pipe will not be damaged during insertion at the proposed pull lengths and geometries.
 5. Description of proposed pipe jointing method.
 6. Descriptions and shop drawings describing and illustrating methods, equipment and materials proposed to align and support the carrier pipe using casing spacers. The submittal shall include as minimum:
 - a. Submit casing spacer manufacturer information and all performance data. Submit material properties, strength, pressure rating, dimensions, installation instructions and recommended spacing.
 - b. Description of method of and equipment used for transporting, preparation, and delivery of the casing spacers.
- C. Construction Submittals. During construction, and within one week after performing each item or before the next construction step, whichever is less, unless specified otherwise, submit the following to the Engineer:
1. Field installation logs that have at minimum: stations and length of carrier pipe installed; Submit logs daily.

1.04 REFERENCE STANDARDS

- A. Unless otherwise noted in these Contract Documents, the standards referenced below shall apply to this Section and shall take precedence. Additional references may be noted in text and/or on the Drawings. Where references are made to standards, the revision in effect at the time of bid opening shall apply.
- B. American Society for Testing and Materials (ASTM)

1. ASTM C905-97 - Standard for Polyvinyl Chloride (PVC Pressure Pipe and Fabricated Fittings, 14 in through 48 in (350mm-1200mm), for Water Distribution.
2. ASTM D1784 - Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
3. ASTM D2321 - Practice for Underground Installation of Flexible Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications.
4. ASTM D2239 - Standard Specification for Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter.
5. ASTM D2241 - Standard Specification for Poly (Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series).
6. ASTM D2447 - Standard Specification for Polyethylene (PE) Plastic Pipe, Schedules 40 and 80, Based on Outside Diameter.
7. ASTM D2774 - Standard Practice for Underground Installation of Thermoplastic Pressure Piping.
8. ASTM D3261 - Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.
9. ASTM D3350 - Standard Specification for Polyethylene Plastics Pipe and Fittings Materials.

PART 2 PRODUCTS

2.01 CASING SPACERS

- A. For casing spacers: 14 gauge bands and 10 gauge risers shall be Type 304 stainless steel; all fasteners and exposed metal shall be stainless steel; bands shall have insulating liners; runners shall be reinforced plastic, DuPont Co. "Rynite" or approved equal. For pipe up to 12-inch diameter, spacers shall be 8-inch long with 1-inch minimum width runners; for pipe larger than 12-inch diameter, spacers shall be 12-inch long with 2-inch minimum width runners. Maximum height of runner above the riser shall be 1½-inch. Number of bottom runners shall be multiples of two. Number of top runners shall be multiples of two.
- B. Casing spacers shall be by Pipeline Seal & Insulator, Inc.; Advance Products & Systems, Inc.; Power-seal Corp.; J-Four Pipeline Products; CCI Piping Systems; The BWM Company; Cascade Waterworks Mfg.; or approved equal.

PART 3 EXECUTION

3.01 PREPARATION

- A. Complete the following preparation, unless approved otherwise by the Engineer. The Engineer makes no guarantee regarding the information, data, and physical condition of underground facilities or existing pipelines.

3.02 GENERAL

- A. Conduct all construction work within limits of disturbance shown on the Drawings. If the Contractor requires additional workspace, he is responsible to coordinate with the Owner's Representative.
- B. The Contractor shall complete the cleaning and slip-lining work in accordance with sequencing as specified in Section 01010 Summary of Work and as shown on the Drawings.

3.03 SAFETY REQUIREMENTS

- A. Methods of construction shall be such as to ensure the safety of the work, project participants, the public, third parties, and adjacent property, whether public or private. As a minimum, all work shall conform to the requirements of OSHA and all federal, state, and local regulations. The Contractor is solely and completely responsible for maintaining safe working conditions at the site at all times.
- B. The Contractor's Safety Officer shall administer an accident prevention program, and shall prepare a code of safe practices and an emergency plan. Provide the Owner with a copy of each prior to starting slip-lining pipe installation. Hold safety meetings and provide safety instruction for new employees.

3.04 PIPE CLEANING

- A. The Contractor shall clean the existing 8-inch TSC piping segments to the extents shown on the Drawings. The Contractor shall flush the system in segments as construction progresses in accordance with project sequencing.
- B. The existing pipe shall be cleaned using an internal high pressure water stream suitable for cleaning and removing any accumulated sludge, grease, grit, Struvite, or any other material that has accumulated in the pipeline.
- C. The cleaning shall occur so that debris and cleaning process water is directed to and collected at the thickeners. At no time shall cleaning process water be discharged on the ground. The cleaning process water and debris shall not be disposed of in existing gravity thickeners process drains, unless notified by Owner. The Contractor shall include all costs for providing pressurized water, debris collection/dewatering, bypass pumping (if needed) and any other incidental costs required to perform the pipe cleaning.
- D. If potable water is used for cleaning from the Owner's water system, the Contractor shall supply a suitable backflow prevention system (FEBCO Model 825 or WATTS Model 909 Backflow Preventor or approved equal) and methodology necessary to protect temporary piping from freezing and damage to vehicular loads. The Owner will supply the Contractor with a suitable water meter to measure water quantity used from the City's potable water lines. Contractor shall pay the Owner for water used at already existing water usage fees. Water drawn from process water lines or system will not be measured. Contractor shall be responsible for payment of all deposits, rental fees, or other charges associated with the use of potable water.

3.05 INSERTION AND PULLING OF MANDREL

- A. A mandrel with a minimum length of one joint of pipe (or 20-ft) shall be pulled completely through each section of existing casing pipe that is to be slip-lined prior to pulling carrier pipe. If the pre-installation inspection with a mandrel reveals an obstruction (such as heavy solids, dropped joints, or collapsed pipe) in the existing pipe that cannot be removed by pipe cleaning equipment, contractor shall perform a point repair prior to slip-lining as approved by the Engineer.

3.06 INSTALLATION

- A. Remove and replace fences, pavement, driveways, sidewalks, curb and gutter, etc. damaged as a result of movement of the construction equipment during the course of the work.
- B. Excavation: Insertion pits shall be located as indicated by the Contractor submittals. If additional insertion pits are required, the Engineer shall approve the insertion pits and their locations prior to the starting of the work. Point repairs, deemed necessary at any point on the existing pipeline by the Engineer will require locating insertion pits at those points. The insertion pit size shall be no larger than is necessary to perform the work. The pit shall be sloped as required by the manufacturer or supplier. The sides of the pit must be supported and conform to OSHA requirements. The insertion pit shall be wide enough to install the carrier pipe without damage to existing casing pipe and other existing piping nearby. Insertion/pulling pits shall be properly backfilled with suitable material as specified to achieve the required compaction.
- C. The work shall be performed in dry conditions. The Contractor shall be responsible for groundwater control.
- D. The carrier pipe can be installed by either pulling or pushing or a combination thereof. During insertion, precautions shall be taken to protect the carrier pipe from scratches and gouges. The liner shall be protected from ragged edges of the existing pipe.

3.07 CASING SPACERS

- A. Install casing spacers to maintain pipe alignment and grade. Install casing spacers per manufacturer product specifications. Forces due to insertion of spacers shall not exceed the pipe manufacturer's recommendation.

3.08 PIPE TESTING

- A. The new scum piping shall be pressure tested and disinfected as specified in Division 2 and 15.

3.09 CLEANUP AND RESTORATION

- A. Perform restoration as the work progresses and when completed as specified. Do not delay restoration work, and complete restoration no later than 30 days after the carrier pipe is in place. Any testing or further inspection necessary for final completion and inspection of the carrier pipe is not cause for any delay of restoration work required per the Contract Documents. Include all property that was affected by the construction operations. Such final restoration that cannot be performed within the 30-day period due to adverse weather conditions may, upon written request and including a proposed procedure and time schedule, be performed as

approved by the Owner. Any delayed restoration will be contingent upon providing suitable safe temporary facilities without inconvenience or nuisance.

END OF SECTION

SECTION 05015
STAINLESS STEEL FABRICATIONS- GENERAL

PART 1 GENERAL

1.01 SUMMARY

- A. Scope: Applies to all stainless steel fabrications as shown on the PLANS. Furnish all plant, labor, supervision, materials, equipment, supplies, tools, and all operations in connection with furnishing, installing, and placing in service stainless steel fabrications.

1.02 RELATED REQUIREMENTS

- A. Other related work as called for on PLANS or specified elsewhere in this or other Technical Specification Sections.

1.03 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

- A. American National Standards Institute (ANSI)

- 1. ANSI B18.2.1 - Square and Hex Bolts and Screws Inch Series

- B. AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

- 1. ASME Section IX - Boiler and Pressure Vessel Code - Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators

- C. AMERICAN SOCIETY OF TESTING AND MATERIALS (ASTM)

- 1. ASTM A167 - Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
- 2. ASTM A193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service
- 3. ASTM A240 - Standard Specification for Heat Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels
- 4. ASTM A276 - Standard Specification for Stainless Steel Bars and Shapes
- 5. ASTM A380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems
- 6. ASTM A967 - Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts

1.04 SUBMITTALS

- A. Furnish large-scale, dimensioned shop drawings showing plan, elevation, and appropriate cross sections. Show piece marks, sizes, drilling, thickness, joint details, and materials. Furnish chemical and physical material certificates for each heat used during manufacture.
- B. Submit welder qualification certificates.
- C. Submit shop testing certificates.
- D. Submit pickling and passivation procedures and material descriptions.

1.05 QUALITY ASSURANCE

- A. Fabrication dimensions and accuracy of fabrication are Contractor's responsibility.
- B. Thoroughly clean any equipment before use in cleaning and fabrication of stainless steel.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Shipping

- 1. Ship factory fabricated assemblies in the largest sections permitted by carrier regulations, properly match-marked for ease of field erection.
- 2. Loose parts (nuts and bolts, etc.) are to be shipped in crates that are clearly marked as to contents.

B. Handling and Unloading

- 1. Unload and handle equipment in accordance with fabricator's instructions.
- 2. Transfer of unprotected stainless steel to be accomplished utilizing nylon straps or stainless steel cables to avoid contact with carbon steel components.

C. Storage

- 1. Store in an area that will avoid damage due to traffic.
- 2. Exposure to normal weather conditions is acceptable; however, avoid contact with other materials like carbon steel, aluminum, concrete, and corrosive chemicals.
- 3. Store materials to avoid contact with the ground.

PART 2 PRODUCTS

2.01 MANUFACTURER(S)

- A. Use materials of domestic manufacture.

2.02 MATERIALS AND/OR EQUIPMENT

- A. General: Materials used in manufacture to be 316L stainless steel unless specifically noted otherwise.
- B. Minimum Material Requirements
 - 1. Stainless Steel Bars and Shapes: ASTM A276
 - 2. Stainless Steel Sheet, Strip, Plate, and Flat Bars: ASTM A666, ASTM A240, or ASTM A167
 - 3. Stainless Steel Bolts and Nuts: ASTM 193

2.03 FABRICATION

- A. General:
 - 1. All fabrication to be performed in a fully equipped fabrication shop.
 - 2. Each piece to be marked with an identification mark that corresponds to the shop drawing to facilitate job site assembly.
- B. Welding
 - 1. All welding is to be qualified and certified in accordance with the requirements of the latest edition of ANSI/AWS D1.1 “Structural Welding Code – Steel” published by the American Welding Society.
 - 2. Fabricate utilizing inert argon gas, shielded arc plasma, MIG or TIG welding procedures.
 - 3. Add filler wire to all welds to provide a cross sectional area of weld and metal thickness equal to or greater than the parent metal. Filler wire to be at least one grade higher than the parent metal and of the extra low carbon grade.
 - 4. Rigid jigs and fixtures are to be utilized for holding parts together in proper alignment while welding.
 - 5. All joints are to be accurately fitted, aligned, and cleaned of foreign material prior to welding.
 - 6. Grind flush all welds on gasket surfaces.
- C. Pickle and passivate all welded stainless steel fabrications by using the following procedure.
 - 1. Wire-brush all outside weld area to remove weld splatter. Brushes are to be stainless steel and are to have been used only on stainless steel.
 - 2. Remove all carbon deposits, greases, and oils by pickling and neutralization to aid the regeneration of a uniform corrosion-resistant chromium oxide film.
 - a. After welding and brushing the weld clean, completely immerse all stainless steel assemblies and parts in a pickling solution of 6% nitric acid and 3% hydrofluoric acid

at a temperature of 140 F for a minimum of 15 minutes or until a mild etch is achieved. In lieu of passivation, a glass bead blast will be acceptable.

- b. Neutralize the pickling solution after cleaning by immersing the assemblies and parts into a solution of tri-sodium phosphate and then rinsing with clean water.

2.04 SOURCE QUALITY CONTROL

- A. Nuts and Bolts: Per ANSI B 18.2, stainless steel, type and grade to prevent galling.

PART 3 EXECUTION

3.01 ERECTION/INSTALLATION/APPLICATION AND/OR CONSTRUCTION

- A. General Requirements

1. PLANS show sizes, elevations, and general arrangement.

3.02 MEASUREMENT AND PAYMENT

- A. No separate measurement and payment for work performed under this Section. Include cost of same in Contract price bid for work of which this is a component part.

END OF SECTION

SECTION 05120
STRUCTURAL STEEL GENERAL

PART 1 GENERAL

1.01 SUMMARY

A. This Section defines the furnishing, fabrication, and installation of various metals for various types of structures and support purposes. The Section includes:

1. Structural steel shapes and plate.
2. Fasteners:
 - a. All thread rods
 - b. Anchor bolts
 - c. Assembly bolts
 - d. Chemical anchors
 - e. Concrete anchors
 - f. Concrete inserts
 - g. Deformed bar anchors
 - h. Eyebolts
 - i. Flush shells
 - j. High strength all thread rods
 - k. High strength bolts
 - l. Powder actuated fasteners
 - m. Sleeve anchors
 - n. Undercut or similar concrete anchors
 - o. Welded studs
3. Isolation sleeves and washers.
4. Thread coating.
5. Welding.

1.02 RELATED REQUIREMENTS

A. Other related work as called for on PLANS or specified elsewhere in this or other TECHNICAL SPECIFICATION Sections.

1.03 REFERENCES

- A. The publications listed below form a part of this Specification to the extent referenced. The publications are referenced to in the text by basic designation only.
- B. American Institute of Steel Construction (AISC)
 1. AISC - Specification for Structural Steel Buildings
- C. American National Standards Institute (ANSI)

1. ANSI B212-15 - Cutting Tools - Carbide-tipped Masonry Drills and Blanks for Carbide-tipped Masonry Drills

D. American Welding Society (AWS)

1. AWS A5.1 - Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding
2. AWS A5.17 - Specification for Carbon Steel Electrodes and Fluxes for Submerged Arc Welding
3. AWS A5.20 - Specification for Carbon Steel Electrodes for Flux Cored Arc Welding
4. AWS D1.1 - Structural Welding Code – Steel
5. AWS D10.4 - Recommended Practices for Welding Austenitic Chromium-Nickel Stainless Steel Piping and Tubing

E. American Society for Testing and Materials (ASTM)

1. ASTM A 29 - Standard Specification for Steel Bars, Carbon and Alloy, Hot-Wrought, General Requirements for
2. ASTM A 36 / A 36M - Standard Specification for Carbon Structural Steel
3. ASTM A 53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded, and Seamless
4. ASTM A 108 - Standard Specification for Steel Bars, Carbon, Cold Finished
5. ASTM A 123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
6. ASTM A 153 / A 153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
7. ASTM A 193 - Standard Specification for Alloy Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
8. ASTM A 240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
9. ASTM A 276 - Standard Specification for Stainless Steel Bars and Shapes
10. ASTM A 307 - Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength
11. ASTM A 325 - Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
12. ASTM A 489 - Standard Specification for Carbon Steel Lifting Eyes

13. ASTM A 490 - Standard Specification for Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength
14. ASTM A 496 - Standard Specification for Steel Wire, Deformed, for Concrete Reinforcement
15. ASTM A 500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
16. ASTM A 501 - Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing
17. ASTM A 992 / A 992M - Standard Specification for Structural Steel Shapes
18. ASTM F 593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs
19. ASTM F 959 - Standard Specification for Compressible-Washer-Type Direct Tension Indicators for Use with Structural Fasteners

F. International Code Council(ICC)

1. IBC 2009 - International Building Code (IBC)
2. ICC-ES AC01 - Acceptance Criteria for Expansion Anchors in Masonry Elements
3. ICC-ES AC58 - Acceptance Criteria for Adhesive Anchors in Masonry Elements
4. ICC-ES AC193 - Acceptance Criteria for Mechanical Anchors in Concrete Elements
5. ICC-ES AC308 - Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements

1.04 SUBMITTALS

A. Furnish the following in accordance with Specification Section 01300, "Submittals".

1. Product data
 - a. Post-installed anchors for use in concrete and masonry.
 - 1) Manufacturer's data including catalog cuts showing materials of construction, finishes, and details of installation for each anchor type.
2. Quality control submittals
 - a. Submit shop drawings of members to be fabricated before starting their fabrication.
 - b. Welder's certificates.
 - c. Submit steel fabricator's certification.
3. Test reports
 - a. Certified copies of mill tests and analyses made in accordance with applicable ASTM standards or reports from a recognized commercial laboratory, including chemical and

tensile properties of each shipment of structural steel or part thereof having common properties.

- b. Current International Code Council Evaluation Service (ICC-ES) Report for each type of post-installed anchors to be used.
- c. Concrete anchor installation test report.

1.05 QUALITY ASSURANCE

A. Qualifications:

1. Perform welding of structural metals with welders who have current AWS certificate for the type of welding to be performed.
2. Steel fabricators shall be certified by the AISC or other certification as recognized and accepted by the local building official having jurisdiction.
3. Notify ENGINEER 24 hours minimum before starting shop or field welding.
4. ENGINEER may check materials, equipment, and qualifications of welders.
5. Remove welders performing unsatisfactory Work, or require them to re-qualify.
6. ENGINEER may use gamma ray, magnetic particle, dye penetrant, or other aids to visual inspection to examine any part of welds or all welds.
7. CONTRACTOR shall bear costs of retests on defective welds.
8. CONTRACTOR shall also bear costs in connection with qualifying welders.

B. Certification:

1. Steel fabricators shall be certified by the AISC or other certification acceptable to the local building official having jurisdiction.

C. Concrete anchor installation test:

1. Prior to installation or use of concrete anchors, perform the following test:
 - a. Furnish not less than four of each type proposed for use, and install anchors in a test block of concrete to specified embedment length.
 - b. Furnish and install one 5/8-inch nut on each concrete anchor and tighten each with an applied torque of 10 foot-pounds.
 - c. Loosen each nut and then retighten with an applied torque load of 10 foot-pounds.
 - d. Visible evidence of turning by a concrete anchor will be cause for ENGINEER to reject concrete anchors.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Packing and shipping: Deliver structural steel free from mill scale, rust, and pitting.
- B. Storage and protection: Until erection and painting, protect from weather items not galvanized or protected by a shop coat of paint.

PART 2 PRODUCTS

2.01 MATERIALS AND/OR EQUIPMENT

- A. Unless otherwise specified or Indicated on the Drawings, materials shall conform to the following:

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

- B. Where stainless steel is welded, use low-carbon stainless steel.
- C. General: Furnish threaded fasteners, except high strength bolts, with flat washers, and self-locking nuts, or lock washers and nuts.
1. Bolt heads and nuts: Hex-type.
 2. Bolts, nuts, and washers: Of domestic manufacture.
 3. Where bolts, including anchor bolts, nuts, washers, and similar fasteners are specified to be galvanized, galvanize in accordance with ASTM A 153 / A 153M.
- D. All thread rods:
1. Type 316 Stainless Steel in accordance with ASTM F 593 for use in wet and moist locations, including:
 - a. Water-containing structures:
 - 1) Below and at water level.
 - 2) Above water level:
 - a) Below top of walls of water-containing structures.
 - b) Under the roof, slab, beam, or walkway of enclosed water-containing structures.
 - 3) Dry side of walls of water-containing structures.
 - b. Pump bases.

2. Type 304 or Type 316 stainless steel in accordance with ASTM F 593 for aluminum assemblies.
 3. ASTM A 36 / A 36M meeting the mechanical requirements of ASTM A 307. Hot-dip galvanize for galvanized assemblies and for applications other than those specified.
- E. All thread rods bonded in holes drilled in concrete with adhesive: As specified in Paragraph 2.01.A and as indicated on the PLANS.
- F. Anchor bolts:
1. Anchor bolts, nuts, and washers: Type 316 stainless steel in accordance with ASTM F 593 for use in wet and moist locations, including:
 - a. Water-containing structures:
 - 1) Below and at water level.
 - 2) Above water level:
 - a) Below top of walls of water-containing structures.
 - b) Under the roof, slab, beam, or walkway of enclosed water-containing structures.
 - 3) Dry side of walls of water-containing structures.
 - b. Pump bases.
 2. Anchor bolts, nuts, and washers: Type 304 or Type 316 stainless steel for fastening aluminum to concrete or steel.
 3. Anchor bolts, nuts, and washers: Hot-dip galvanized ASTM A 307 steel bolt or hot-dip galvanized ASTM A 36 / A 36M steel, for applications other than those specified.
- G. Assembly bolts:
1. Bolts, nuts, and washers for wood baffles, collectors, and other field-assembled construction: Type 316 stainless steel in accordance with ASTM F 593 for use in wet and moist locations, including:
 - a. Water-containing structures:
 - 1) Below and at water level.
 - 2) Above water level:
 - a) Below top of walls of water-containing structures.
 - b) Under the roof, slab, beam, or walkway of enclosed water-containing structures.
 - c) Dry side of walls of water-containing structures.
 - b. Pump bases.
 2. Type 304 or Type 316 stainless steel in accordance with ASTM F 593 for aluminum assemblies.
 3. Hot-dip galvanized ASTM A 307 steel for galvanized assemblies and for applications other than those specified.
- H. Chemical anchors:
1. All-thread rods shall be either ASTM A 36 / A 36M steel or stainless steel.

2. Hot-dip galvanize or zinc plate ASTM A 36 / A 36M steel all-thread rods.
 3. Stainless steel all-thread rod shall conform with ASTM F 593 and shall be used for corrosive conditions where indicated on the PLANS.
 4. Do not use chemical anchors to resist tension in overhead positions.
 5. Chemical anchors for anchorage to concrete:
 - a. Chemical anchors shall have current ICC Evaluation Service Report that demonstrates compliance with ICC-ES AC308 for cracked concrete.
 - b. Manufacturers: One of the following or approved equal:
 - 1) Simpson: SET-XP (ICC ESR-250B)
 - 2) Hilti: HIT-RE 500-SD (ICC ESR-2322)
 - 3) Hilti: HIT-HY 200 (ICC ESR-3187)
 6. Chemical anchors for anchorage to masonry (solid or solid grouted):
 - a. Chemical anchors shall have current ICC Evaluation Service Report that demonstrates compliance with ICC AC58.
 - b. Manufacturers: One of the following or approved equal:
 - 1) Simpson: SET (ICC ESR-1772)
 - 2) Hilti: HIT-HY 150 MAX (ICC ESR-1967) (Grouted)
 - 3) Hilti: HIT-HY 70 (ICC ESR-3342) (Ungouted)
- I. Concrete mechanical and screw anchors:
1. Expansion and screw anchors anchorage to concrete:
 - a. Concrete anchors shall have current ICC Evaluation Service Report that demonstrates compliance with ICC AC193 for cracked concrete.
 - b. Manufacturers: One of the following or approved equal:
 - 1) Simpson: STRONG-BOLT 2 (ICC ESR-3037)
 - 2) Simpson: TITEN HD (ICC ESR-2713)
 - 3) Hilti: Kwik HUS-EZ (ICC ESR-3027)
 2. Expansion and screw anchors anchorage to masonry:
 - a. Masonry anchors shall have current ICC Evaluation Service Report that demonstrates compliance with ICC AC 01.
 - b. Manufacturers: One of the following or approved equal:
 - 1) Simpson: WEDGE-ALL (ICC ESR-1396)
 - 2) Simpson: TITEN HD (ICC ESR-1056)
 - 3) Hilti: Kwik Bolt 3 (ICC ESR-1385)
 - 4) Hilti: Kwik HUS-EZ (ICC ESR-3056)
 3. Concrete anchor's integral threaded stud, wedge, washer, and nut: Type 304 or Type 316 stainless steel in accordance with ASTM F 593. For use in wet and moist locations, including:
 - a. Water-containing structures:
 - 1) Below and at water level.
 - 2) Above water level:
 - a) Below top of walls of water-containing structures.
 - b) Under the roof, slab, beam, or walkway of enclosed water-containing structures.

- 3) Dry side of walls of water-containing structures.
 - b. Pump bases.
 4. Concrete anchor's integral threaded stud, wedge, washer, and nut: Type 304 or 316 stainless steel in accordance with ASTM F 593 for fastening aluminum to concrete or steel.
 5. Concrete anchor's integral threaded stud, wedge, washer, and nut: Hot-dip galvanized carbon steel, for applications other than those specified.
 6. Do not use slug-in, lead cinch, and similar systems relying on deformation of lead alloy or similar materials in order to develop holding power.
- J. Concrete inserts: 1 piece, hot-dip galvanized, integrally hot forged unit fabricated from steel meeting ASTM A 29 Hot Rolled Grade 1045 requirement. Manufacturers: One of the following or approved equal:
1. Dayton Superior, F-54 Ductile Embedded Insert.
- K. Deformed bar anchors: In accordance with ASTM A 496:
1. Manufacturers: One of the following or approved equal:
 - a. Nelson Stud Welding Company, D2L Deformed Bar Anchors.
 - b. Stud Welding Products, DBA (Deformed Bar) Anchors.
- L. Eyebolts:
1. Welded or forged, when manufactured of materials other than carbon steel.
 2. Having geometric and strength characteristics of eyebolts specified in ASTM A 489, Type 1. The strength characteristics include proof load requirements, breaking strength requirements, tensile strength requirements, bend test, and impact strength.
- M. Flush shells:
1. Manufacturers: One of the following or approved equal:
 - a. Simpson Strong-Tie, Drop-In or Blue Banger Hanger.
 - b. Hilti Incorporated, HDI Drop-In.
 2. Bolts, flush shells, threaded rods, washers, and nuts: Type 303 stainless steel in accordance with ASTM F 593.
- N. High strength all thread rods: In accordance with ASTM A 193, Grade B7, hot-dip galvanized.
- O. High strength bolts: High strength bolts, nuts, and hardened flat washers shall be in accordance with ASTM A 325 or ASTM A 490, as indicated on the PLANS.
- P. Powder actuated fasteners:
1. For installation in concrete or steel: Zinc coated, heat-treated, alloy steel.

2. Fasteners not sufficiently protected against corrosion from exposure to corrosive conditions: Coat as necessary to make suitable for such conditions.
3. Pins: Furnish with head or threaded stud capable of transmitting loads to shank.
4. Pins connected to steel: Furnish with longitudinal serrations around circumference of shank.

Q. Sleeve anchors:

1. Sleeve anchors for anchorage to concrete:
 - a. Sleeve anchors shall have current ICC Evaluation Service Report that demonstrates compliance with ICC AC193 for cracked concrete.
 - b. Manufacturers: One of the following or approved equal:
 - 1) Hilti: HSL-3 (ICC ESR-1545)
2. Sleeve anchors for anchorage to masonry:
 - a. Sleeve anchors shall have current ICC Evaluation Service Report that demonstrates compliance with ICC AC 01.
 - b. Manufacturers: One of the following or approved equal:
 - 1) Simpson: Sleeve-All
3. Use stainless material for aluminum and stainless attachments and carbon steel for steel attachments.
4. For use in wet and moist locations, including locations listed below. Use Type 304 stainless steel in accordance with ASTM F 593 for sleeve anchor's internal bolt, expansion sleeve, extension sleeve, and washer. Use Type 303 stainless steel in accordance with ASTM F 593 for sleeve anchors expansion cone.
 - a. Water-containing structures:
 - 1) Below and at water level.
 - 2) Above water level:
 - a) Below top of walls of water-containing structures.
 - b) Under the roof, slab, beam, or walkway of enclosed water-containing structures.
 - 3) Dry side of walls of water-containing structures.
 - b. Pump bases.
5. For fastening aluminum to concrete or steel, use Type 304 stainless steel in accordance with ASTM F 593 for sleeve anchor's internal bolt, expansion sleeve, extension sleeve. Use Type 303 stainless steel in accordance with ASTM F 593 for sleeve anchor's expansion cone.
6. For applications other than those specified above, use hot-dip galvanized carbon steel for sleeve anchor's internal bolt, expansion sleeve, expansion cone, extension sleeve, and washer.
7. The sleeve anchor shall have a nylon compression ring which compresses to ensure that the material being fastened is tightly secured against the concrete.

8. Do not use slug-in, lead cinch, and similar systems relying on deformation of lead alloy or similar materials in order to develop holding power.
- R. Undercut concrete anchors:
1. Materials: In accordance with ASTM A 193, Grade B7. hot-dip galvanized.
 2. Manufacturers: One of the following or approved equal:
 - a. Simpson: TORQ-CUT (ICC ESR-2705)
 - b. Hilti: HDA Undercut (ICC ESR-1546)
- S. Welded studs:
1. ASTM A 108 with 50,000-pounds per square inch minimum yield strength, and 60,000-pounds per square inch minimum tensile strength.
 2. Headed studs: Manufacturers: One of the following or approved equal:
 - a. Nelson Stud Welding Company, S3L Shear Connectors or H4L Concrete Anchors (HCA).
 - b. Stud Welding Products, Headed Concrete Anchors or Shear Connectors.
- T. Isolating Sleeves and Washers:
1. Manufacturers: One of the following or approved equal:
 - a. Central Plastics Company, Shawnee, Oklahoma.
 - b. Corrosion Control Products, PSI Inc., Gardena, CA.
 2. Sleeves: Mylar, 1/32 inch thick, 4,000 volts per mil dielectric strength, of proper size to fit bolts and extending half way into both steel washers.
 - a. 1 sleeve required for each bolt.
 3. Washers: The inside diameter of all washer shall fit over the isolating sleeve and both the steel and isolating washers shall have the same inside diameter and outside diameter.
 - a. Proper size to fit bolts. Two insulating washers are required for each bolt.
 - b. Two 1/8-inch thick steel washers for each bolt.
 4. G3 Phenolic:
 - a. Thickness: 1/8 inch
 - b. Base material: Glass
 - c. Resin: Phenolic
 - d. Water absorption: 2 percent
 - e. Hardness (Rockwell): 100
 - f. Dielectric strength: 450 volts per mil
 - g. Compression strength: 50,000 pounds per square inch
 - h. Tensile strength: 20,000 pounds per square inch
 - i. Maximum operating temperature: 350 degrees Fahrenheit
- U. Galvanizing Surface Repair: Manufacturers: One of the following or approved equal:
1. Galvinox

2. Galvo-Weld

V. Thread Coating: Manufacturers: One of the following or approved equal:

1. Never Seez Compound Corporation, Never-Seez.
2. Oil Research, Inc., WLR No. 111.

W. Supplementary Parts: Furnish as required for complete structural steel erection, whether or not such parts and Work are specified or indicated on the PLANS.

2.02 FABRICATION

A. Shop assembly:

1. Fabricate structural steel in conformance with AISC "Specification for the Structural Steel Buildings" unless otherwise specified or modified by applicable regulatory requirements.
2. Where anchors, connections, or other details of structural steel are not specifically indicated on the PLANS or specified, their material, size and form shall be equivalent in quality and workmanship to items specified.
3. For Structural members such as W shapes, S shapes, channels, angles, and similar members not available in quantity, size, and type of stainless steel specified or indicated on the PLANS.
 - a. Fabricate by welding together pieces of low carbon stainless steel plate, such as Type 316L.
 - b. Make full penetration welds between pieces of plate to attain same or higher section modulus and moment of inertia as members indicated on the PLANS.
4. Where galvanizing is required, hot-dip galvanize structural steel after fabrication in accordance with ASTM A 123:
 - a. Do not electro-galvanize or mechanically-galvanize unless specified or accepted by ENGINEER.
 - b. Re-straighten galvanized items that bend or twist during galvanizing.
5. Round off sharp and hazardous projections and grind smooth.
6. Take measurements necessary to properly fit work in the field. Take responsibility for and be governed by the measurements and proper working out of all the details.
7. Take responsibility for correct fitting of all metal work.

PART 3 EXECUTION

3.01 PREPARATION

- A. Verification of conditions: Examine Work in place to verify that it is satisfactory to receive the Work of this Section. If unsatisfactory conditions exist, do not begin this Work until such conditions have been corrected.

3.02 ERECTION/INSTALLATION/APPLICATION AND/OR CONSTRUCTION

A. General:

1. Fabricate structural and foundry items to true dimensions without warp or twist.
2. Form welded closures neatly, and grind off smooth where weld material interferes with fit or is unsightly.
3. Install structural items accurately and securely, true to level, plumb, in correct alignment and grade, with all parts bearing or fitting structure or equipment for which intended.
4. Do not cock out of alignment, redrill, reshape, or force fit fabricated items.
5. Place anchor bolts or other anchoring devices accurately and make surfaces that bear against structural items smooth and level.
6. Rigidly support and brace structural items needing special alignment to preserve straight, level, even, and smooth lines. Keep structural items braced until concrete, grout, or dry pack mortar has hardened for a minimum of 48 hours.
7. Erect structural steel in conformance with AISC "Specification for Structural Steel Buildings" unless otherwise specified or modified by applicable regulatory requirements.
8. Where anchors, connections, and other details of structural steel erection are not specifically indicated on the Drawings or specified, form, locate, and attach with equivalent in quality and workmanship to items specified.
9. Round off sharp or hazardous projections and grind smooth.
10. Paint or coat steel items as specified in Section 09902.

B. Welding - General:

1. Make welds full penetration type, unless otherwise indicated on the PLANS.
2. Remove backing bars and weld tabs after completion of weld. Repair defective welds observed after removal of backing bars and weld tabs.

C. Welding stainless steel:

1. General: Comply with AWS D1.1.
 - a. Perform with electrodes and techniques in accordance with AWS D10.4.

D. Welding carbon steel:

1. General: Comply with AWS D1.1:
 - a. Weld ASTM A 36 / A 36M and A 992 / A 992M structural steel, ASTM A 500 and A 501 structural tubing, and ASTM A 53 pipe with electrodes conforming to AWS A5.1, using E70XX electrodes; AWS A5.17, using F7X-EXXX electrodes; or AWS A5.20, using E7XT-X electrodes:

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

E. Interface with other products:

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

F. Fasteners:

1. General:
 - a. Install bolts, including anchor bolts and concrete anchors, to project 2 threads minimum, but 1/2 inch maximum beyond nut.
 - b. Unless otherwise specified, tighten bolts, including anchor bolts and concrete anchors, to the "snug-tight" condition, defined as tightness attained by a few impacts of an impact wrench or the full effort of a man using an ordinary spud wrench.
2. All thread rods bonded in drilled holes in concrete with epoxy: As specified in Contract and as indicated on the PLANS.
3. Anchor bolts:
 - a. Cast-in-place when concrete is placed.
 - b. Accurately locate anchor bolts embedded in concrete with bolts perpendicular to surface from which they project.
 - c. Do not allow anchor bolts to touch reinforcing steel.
 - d. Where anchor bolts are within 1/4 inch of reinforcing steel, isolate with a minimum of 4 wraps of 10-mil polyvinyl chloride tape in area adjacent to reinforcing steel.
 - e. In anchoring machinery bases subject to heavy vibration, use 2 nuts, with 1 serving as a locknut.
 - f. Where bolts are indicated on the PLANS for future use, first coat thoroughly with non-oxidizing wax, then turn nuts down full depth of thread and neatly wrap exposed thread with waterproof polyvinyl tape.
 - g. Furnish anchor bolts with standard hex bolt head or an equivalent head acceptable to ENGINEER unless otherwise indicated on the PLANS. "L" or "J" anchor bolts are not equivalent to an anchor bolt with a hex bolt head.
 - h. Minimum anchor bolt embedment: 12-bolt diameters, unless longer embedment is indicated on the PLANS.
 - i. Where indicated on the PLANS, set anchor bolts in metal sleeves having inside diameter approximately 2 inches greater than bolt diameter and minimum 10-bolt diameters long. Fill sleeves with grout when a machine or other equipment is grouted in place.
 - j. Anchor bolts may be cast in concrete in lieu of using concrete anchors.
4. Chemical anchors:
 - a. Install anchors in accordance with approved ICC Evaluation Service Report. Where conflict exists between the approved ICC Evaluation Service Report and the requirements herein, the requirements of the Evaluation Service Report shall control.

- b. Accurately locate concrete anchors and set perpendicular to surfaces from which they project.
 - c. Drilling holes:
 - 1) Do not damage or cut existing reinforcing bars, electrical conduits, or other items embedded in the existing concrete without acceptance by ENGINEER.
 - 2) Determine location of reinforcing bars, or other obstructions with a non-destructive indicator device.
 - d. Hole drilling equipment:
 - 1) Electric or pneumatic rotary type with light or medium impact.
 - 2) Drill bits: Carbide-tipped in accordance with ANSI B212-15.
 - 3) Hollow drills with flushing air systems are preferred. Air shall be free of oil, water, or other contaminants which will reduce bond.
 - 4) Where edge distances are less than 2 inches, use lighter impact equipment to prevent micro-cracking and concrete spalling during drilling process.
 - e. Hole diameter:
 - 1) As recommended by chemical anchor manufacturer.
 - f. Install all thread rods to depth, spacing's, and locations as indicated on the PLANS.
 - g. Cleaningholes:
 - 1) Insert long air nozzle into hole and blow out loose dust. Use air which is free of oil, water, or other contaminants which will reduce bond.
 - 2) Use a stiff bristle brush to vigorously brush hole to dislodge compacted drilling dust.
 - 3) Repeat step 1.
 - 4) Repeat above steps as required to remove drilling dust or other material which will reduce bond. The hole shall be clean and dry.
 - h. Cleaning all thread rods:
 - 1) Degrease over embedment length. The all thread rods shall be free of oil, grease, paint, dirt, mill scale, rust, or other coatings that will reduce bond.
5. Concrete anchors:
- a. Do not use concrete anchors in lieu of anchor bolts.
 - b. Install anchors in accordance with approved ICC Evaluation Service Report. Where conflict exists between the approved ICC Evaluation Service Report and the requirements herein, the requirements of the Evaluation Service Report shall control.
 - c. Accurately locate concrete anchors and set perpendicular to surfaces from which they project.
 - d. Minimum embedment lengths:

| Diameter Inches | Embedment Length Inches |
|----------------------------|------------------------------------|
| 1/4 | 2 |
| 3/8 | 2-1/2 |
| A. 1/2 | B. 4-1/8 |
| 5/8 | 4-1/2 |
| 3/4 | 6-1/2 |

- e. Drilling holes:

- 1) Do not damage or cut existing reinforcing bars, electrical conduits, or other items embedded in the existing concrete without acceptance by ENGINEER.
 - 2) Determine location of reinforcing bars, or other obstructions with a non-destructive indicator device.
 - 3) Remove dust and debris from hole using compressed air.
 - f. Hole drilling equipment:
 - 1) Electric or pneumatic rotary type with light or medium impact.
 - 2) Drill bits: Carbide-tipped in accordance with ANSI B212-15.
 - 3) Hollow drills with flushing air systems are preferred.
 - 4) Where edge distances are less than 2 inches, use lighter impact equipment to prevent micro-cracking and concrete spalling during drilling process.
6. Deformed bar anchors:
- a. Butt weld with automatic stud welding gun as recommended by manufacturer.
 - b. Ensure butt weld develops full strength of the anchor.
7. Flush shells:
- a. Use only where specifically indicated on the Drawings.
 - b. Install anchors in accordance with approved ICC Evaluation Service Report. Where conflict exists between the approved ICC Evaluation Service Report and the requirements herein, the requirements of the Evaluation Service Report shall control.
 - c. Accurately locate and set perpendicular to surfaces from which they project.
 - d. Drilling holes:
 - 1) Do not damage or cut existing reinforcing bars, electrical conduits, or other items embedded in the existing concrete without acceptance by ENGINEER.
 - 2) Determine location of reinforcing bars, or other obstructions with a non-destructive indicator device.
 - 3) Remove dust and debris from hole using compressed air.
 - e. Hole drilling equipment:
 - 1) Electric or pneumatic rotary type with light or medium impact.
 - 2) Drill bits: Carbide-tipped in accordance with ANSI B212-15.
 - 3) Hollow drills with flushing air systems are preferred.
 - 4) Where edge distances are less than 2 inches, use lighter impact equipment to prevent micro-cracking and concrete spalling during drilling process.
8. High strength bolts:
- a. Consider connections with high strength bolts to be slip critical structural connections, unless otherwise indicated on the PLANS.
 - b. Connections with high strength bolts shall conform to AISC Specification for Structural Joints Using ASTM A 325 or A 490 Bolts.
 - c. Furnish hardened flat washer:
 - 1) Under element, nut, or bolt head, turned in tightening.
 - 2) On outer plies for short slotted holes.
 - d. Verify adequate tightening of bolts by means of tension indicator washers placed as indicated in ASTM F 959, Figure 1.
9. Powder actuated fasteners: Use powder actuated fasteners only for applications indicated on the PLANS or specified.
10. Sleeve anchors:
- a. Do not use sleeve anchors in lieu of anchor bolts.

- b. Install anchors in accordance with approved ICC Evaluation Service Report. Where conflict exists between the approved ICC Evaluation Service Report and the requirements herein, the requirements of the Evaluation Service Report shall control.
- c. The sleeve anchor bolt shall be removable and the expansion sleeve shall be flush with the concrete surface when installed.
- d. Accurately locate sleeve anchors and set perpendicular to surfaces from which they project.
- e. Minimum embedment lengths:

| Diameter Inches | Embedment Length Inches |
|--------------------|----------------------------|
| C. ¼ | D. 1-3/4 |
| 3/8 | 2-1/2 |
| ½ | 3-1/2 |
| 5/8 | 4 |
| ¾ | 4-1/2 |

- f. Drilling holes:
 - 1) Do not damage or cut existing reinforcing bars, electrical conduits, or other items embedded in the existing concrete without acceptance by ENGINEER.
 - 2) Determine location of reinforcing bars, or other obstructions with a non-destructive indicator device.
 - 3) Remove dust and debris from hole using compressed air.
- g. Hole drilling equipment:
 - 1) Electric or pneumatic rotary type with light or medium impact.
 - 2) Drill bits: Carbide-tipped in accordance with ANSI B212-15.
 - 3) Hollow drills with flushing air systems are preferred.
 - 4) Where edge distances are less than 2 inches, use lighter impact equipment to prevent micro-cracking and concrete spalling during drilling process.

11. Welded studs:

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

12. Undercut anchors:

- a. Install anchors in accordance with approved ICC Evaluation Service Report. Where conflict exists between the approved ICC Evaluation Service Report and the requirements herein, the requirements of the Evaluation Service Report shall control.
- b. Accurately locate concrete anchors and set perpendicular to surfaces from which they project.
- c. Drilling holes:
 - 1) Do not damage or cut existing reinforcing bars, electrical conduits, or other items embedded in the existing concrete without acceptance by ENGINEER.
 - 2) Determine location of reinforcing bars, or other obstructions with a non-destructive indicator device.
- d. Hole drilling equipment:
 - 1) Electric or pneumatic rotary type with light or medium impact.
 - 2) Drill bits: Carbide-tipped in accordance with ANSI B212-15.

- 3) Hollow drills with flushing air systems are preferred.
- 4) Where edge distances are less than 2 inches, use lighter impact equipment to prevent micro-cracking and concrete spalling during drilling process.
- 5) Undercut bottom of hole using cutting tools manufactured for this purpose by undercut anchor manufacturer.

3.03 MEASUREMENT AND PAYMENT

- A. Unless otherwise indicated, no separate measurement or payment for work performed under this Section. Include cost of same in Contract price bid for work of which this is a component part.

END OF SECTION

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SECTION 05500
METAL FABRICATIONS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:

1. Metal grating stair tread,
2. Aluminum stair nosing,
3. Concrete inserts,
4. Ladders,
5. Metal gratings,
6. Metal tread plate,
7. Stairs,
8. Miscellaneous metals, and
9. Associated accessories to the above items.

1.02 RELATED REQUIREMENTS

- A. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
- B. It is the CONTRACTOR's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of the CONTRACTOR's Work.

1.03 REFERENCES

- A. The publications listed below for a part of this specification to the extent referenced. The publications are referenced in the text by basic designation only.
- B. Aluminum Association (AA):
 1. Specification M12-C22-A41 - Aluminum Finishes.
- C. American Association of State Highway and Transportation Officials (AASHTO):
 1. Standard Specifications for Highway Bridges.
- D. American Society for Testing and Materials (ASTM):
 1. A 36/A 36M - Standard Specification for Structural Steel.

2. A 48 - Standard Specification for Grey Iron Castings.
3. A 53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded, and Seamless.
4. A 123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
5. A 240 - Standard Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels.
6. A 269 - Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service.
7. A 276 - Standard Specification for Stainless Steel Bars and Shapes.
8. A 307 - Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
9. A 325 - Standard Specification for High-Strength Bolts for Structural Steel Joints.
10. A 489 - Standard Specification for Carbon Steel Lifting Eyes.
11. A 490 - Standard Specification for Heat-Treated Steel Structural Bolts, 150 ksi Minimum Tensile Strength.
12. A 500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
13. A 501 - Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.
14. A 569 - Standard Specification for Steel, Carbon (0.15 Maximum, Percent) Hot-Rolled Sheet and Strip Commercial Quality.
15. A 570/A 570M - Standard Specification for Steel, Sheet and Strip, Carbon. Hot-Rolled, Structural Quality.
16. A 635/A 635M - Standard Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Carbon, Hot-Rolled.
17. A 653/A 653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
18. [A 992/A 992M - Standard Specification for Structural Steel Shapes.]
19. B 209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
20. B 221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.
21. B 308 - Standard Specification for Aluminum-Alloy 6061-T6 Standard Structural Profiles.

22. B 429 - Standard Specification for Aluminum-Alloy Extruded Structural Pipe and Tube.
23. F 593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws and Studs.

E. American Welding Society (AWS):

1. Standard Symbols for Welding, Brazing, and Nondestructive Examination.

F. National Association of Architectural Metal Manufacturers (NAAMM):

1. Metal Finishes Manual.

G. Occupational Safety and Health Administration (OSHA):

1. Code of Federal Regulations (CFR), Title 29, Labor, Pt. 1900-1990.

1.04 SUBMITTALS

A. Product Data:

1. Metal grating stair tread.
2. Aluminum stair nosing.
3. Metal grating.

B. Shop Drawings:

1. Ladders.
2. Metal grating.
3. Metal tread plate.
4. Stairs.
5. Miscellaneous metals.

C. Quality Control Submittals:

1. Design data and calculations. Stairs and ladders to include drawings and calculations, signed and sealed by ENGINEER registered in the State of Texas.
2. Test Reports:
 - a. Gratings:
 - 1) Grating manufacturers' calculations showing that gratings will meet specified design load, stress, and deflection requirements for each size grating for each span.
 - 2) Reports of tests performed.

PART 2 PRODUCTS

2.01 MATERIALS

- A. General: Unless otherwise specified or indicated on the Drawings, structural and miscellaneous metals shall conform with the standards of the ASTM, including the following:

| Item | ASTM Standard No. | Class, Grade Type or Alloy No. |
|---|-------------------|--|
| Cast Iron | | |
| Cast Iron | A 48 | Class 40B |
| Steel | | |
| Galvanized sheet iron or steel | A 653 | Coating G90 |
| Black steel, sheet or strip | A 569 | -- |
| | A 570 | -- |
| Coil (plate) | A 635 | -- |
| Structural plate, bars, rolled shapes, and miscellaneous items (except W shapes). | A 36 | -- |
| Rolled W shapes | A 992 | Grade 50 |
| Standard bolts, nuts, and washers | A 307 | -- |
| High strength bolts, nuts, and hardened flat washers | A 325 | -- |
| | A 490 | -- |
| Eyebolts | A 489 | Type 1 |
| Tubing, cold-formed | A 500 | -- |
| Tubing, hot-formed | A 501 | -- |
| Steel pipe | A 53 | Grade B |
| Stainless steel | | |
| Plate, sheet, and strip | A 240 | Type 304* or 316** |
| Bars and shapes | A 276 | Type 304* or 316** |
| Bolts (Type 304) | F593 | Group 1 Condition CW |
| Bolts (Type 316) | F593 | Group 2 Condition CW |
| Aluminum | | |
| Flashing sheet aluminum | B 209 | Alloy 5005-H14, 0.032 inches minimum thickness |
| Structural sheet aluminum- | B 209 | Alloy 6061-T6 |
| Structural aluminum | B 209 | Alloy 6061-T6 |
| | B 308 | |
| Extruded aluminum | B 221 | Alloy 6063-T42 |
| * Use Type 304L if material will be welded. | | |
| ** Use Type 316L if material will be welded. | | |

1. Stainless steels are designated by type or series defined by ASTM.

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

2.02 MANUFACTURED UNITS

A. Metal Grating Stair Tread:

1. Material: Welded steel grating tread with non-slip nosing and integral end plates for bolt on attachment to stair stringers. Manufactured and galvanized per subsection 2.02.E.3. below.
2. Size:
 - a. Tread Width: To equal tread spacing plus 1 inch minimum.
 - b. Tread Length: Length to suit stringer to stringer dimension indicated on the Drawings.
 - c. Depth: 1-3/4 inches.
3. Bolts: Type 304 stainless steel.

B. Aluminum Stair Nosing:

1. Manufacturers: One of the following or equal:
 - a. Wooster Products, Inc., Type 101 Nosing.
 - b. American Safety Tread Co., Inc., Style 801 Nosing.
2. Material: Cast aluminum abrasive nosings with aluminum oxide granules integrally cast into metal, forming permanent, nonslip, long-wearing surface.
3. For installation in cast-in-place stairs.
4. Configuration: 4 inches wide, fabricated with integrally cast stainless steel anchors at approximately 12-inch centers. Length to extend within 3 inches of stair edge on each side.

C. Concrete Inserts:

1. Concrete inserts for supporting pipe and other applications are specified in Section 15061.

D. Ladders:

1. General:
 - a. Type: Safety type conforming to local, State, and Occupational Safety and Health Administration standards as minimum. Furnish guards for ladder wells.
 - b. Size: 18 inches wide between side rails of length, size, shape, detail, and location indicated on the Drawings.
2. Metal Ladders:
 - a. Materials: 6063-T5 aluminum alloy, except where submerged or where specifically called for: Type 304L stainless steel.
 - b. Rungs:
 - 1) Corrugated, dimpled, skid-resistance and shaped to prevent slipping off the end of rung.
 - 2) Capable of withstanding 1,000-pound load without failure.
 - c. Side Rails: Minimum 4-inch by 1/2-inch flat bars.

- d. Fabrication:
 - 1) Welded construction, of size, shape, location, and details indicated on the Drawings.
 - 2) For ladders over 20 feet high, fall prevention system designed in accordance with State and Occupational Safety and Health Administration requirements.
- e. Fall Prevention System: Include but not limit to railing, brackets, clamps, 2 sleeves, and 2 belts, satisfying Occupational Safety and Health Administration safe climbing requirements:
 - 1) Manufacturers: One of the following or equal:
 - a) North Consumer Products, Saf-T-Climb.

E. Metal Gratings:

- 1. General:
 - a. Fabricate grating to cover areas indicated on the Drawings.
 - b. Unless otherwise indicated on the Drawings, grating over an opening shall cover entire opening.
 - c. Make cutouts in grating where required for equipment access or protrusion, including valve operators or stems, and gate frames.
 - d. Band Ends of Grating and Edges of Cutouts in Grating:
 - 1) End Banding: 1/4 inch less than height of grating, with top of grating and top edge of banding flush.
 - 2) Cutout Banding: Full-height of grating.
 - 3) Use banding of same material as grating.
 - 4) Panel Layout: Enable installation and subsequent removal of grating around protrusions or piping.
 - 5) Openings 6 Inches and Larger: Lay out grating panels with edges of 2 adjacent panels located on centerline of opening.
 - 6) Openings smaller than 6 Inches: Locate opening at edge of single panel.
 - 7) Where an area requires more than 1 grating section to cover area, clamp adjacent grating sections together at 1/4-points with fasteners acceptable to ENGINEER.
 - 8) Fabricate grating in units of maximum 50 pounds each.
 - e. When requested by ENGINEER, test 1 section of each size grating for each span length involved on the job under full load:
 - 1) Furnish a suitable dial gauge for measuring deflections.
 - f. Grating shall be galvanized steel, unless otherwise specified or indicated on the Drawings.
- 2. Aluminum Grating:
 - a. Material for Gratings, Shelf Angles, and Rebates: 6061-T6 or 6063-T6 aluminum alloy, except cross bars may be 6063-T5 aluminum alloy.
 - b. Shelf Angle Concrete Anchors: Type 304 or Type 316 stainless steel.
 - c. Grating Rebate Rod Anchors: 6061-T6 or 6063-T6 aluminum alloy.
 - d. Bar Size and Spacing: As determined by manufacturer to enable grating to support design load.
 - e. Design Live Load: A minimum of 150 pounds per square foot uniform live load on entire grating area, but not less than the live load indicated on the Drawings for the area where grating is located.
 - f. Maximum Fiber Stress for Design Load: 12,000 pounds per square inch.
 - g. Maximum Deflection Due to Design Load: 1/240 of grating clear span.

- h. Maximum Spacing of Main Grating Bars: 1-1/8 inches clear between bars.
 - i. Minimum Grating Height: 1-1/2 inches.
 - j. Manufacturers: One of the following or equal:
 - 1) IKG Borden Industries.
 - 2) Seidelhuber Metal Products, Inc., grooved I-Bar.
3. Steel Gratings:
- a. Hot-dip galvanized in accordance with ASTM A 123.
 - b. Bar Size and Spacing: Shall meet NAAMM of W-19-4 (1"x 3/16") and as determined by the manufacturer to support design load.
 - c. Design Live Load: A minimum of 150 pounds per square foot uniform live load on the entire area of the grating area, but not less than the live load indicated on the Drawings for the area where the grating is located.
 - d. Maximum Fiber Stress for Design Load: 18,000 pounds per square inch.
 - e. Maximum Deflection Under Design Load: 1/240 of grating clear span.
 - f. Bar Spacing: Maximum of 1-1/8 inches clear between bars.
 - g. Manufacturers: One of the following or equal:
 - 1) McNichols Company.
 - 2) IKG Borden Industries, IKG Weldforged.
 - 3) Seidelhuber Metal Products, Inc., Type 19W4.
4. Heavy-Duty Steel Grating:
- a. Heavy-duty type, fabricated from structural steel and designed in accordance with AASHTO Standard Specifications for Highway Bridges, using HS-20 loading.
 - b. Hot-dip galvanized after fabrication in accordance with ASTM A 123.
 - c. Manufacturers: One of the following or equal:
 - 1) McNichols Company.
 - 2) IKG Borden Industries, Heavy Duty Steel Grating.
 - 3) Seidelhuber Metal Products, Inc., equivalent product.
- F. Metal Tread Plate:
- 1. Plate having a raised figured pattern on 1 surface to provide improved traction.
- G. Stairs:
- 1. Steel Stairs:
 - a. Ships ladders shall conform to local, State, and Occupational Safety and Health Administration Standards as minimum.
 - b. Design of Metal Stairs is specified in Section 05511.
 - c. Stringers: Structural steel channels or plates.
 - d. Treads: See 2.02.A, above
 - e. Railings: Aluminum per Section 05520.
 - f. Anchors: Welded or bolted brackets designed for support and anchorage at top and bottom.
 - g. Finish: Hot-dip galvanized in accordance with ASTM A 123.
 - 2. Aluminum Stairs:

Structural adequacy of the Aluminum stair design is the responsibility of the stair manufacturer's designer.

- a. Ships ladders shall conform to local, State, and Occupational Safety and Health Administration (OSHA) Standards as minimum.
- b. Design of Aluminum stairs shall be in accordance with the current versions of the Aluminum Design Manual (AA-ADM), OSHA Standards American Welding Society (AWS) D1.2.
- c. Stringers: Structural Aluminum channels or plates.
- d. Treads: See 2.02.A, above
- e. Railings: Aluminum per Section 05520.
- f. Anchors: Welded or bolted brackets designed for support and anchorage at top and bottom.
- g. Finish: Class I, clear anodized finish per AA-M12 C22 A41

H. Miscellaneous Metal:

1. Miscellaneous Aluminum: Fabricate aluminum products, not covered separately herein, in accordance with the best practices of the trade and field assemble by riveting or bolting. Do not weld or flame cut.
2. Miscellaneous Cast Iron:
 - a. General:
 - 1) Tough, gray iron, free from cracks, holes, swells, and cold shuts.
 - 2) Quality such that hammer blow will produce indentation on rectangular edge of casting without flaking metal.
 - 3) Before leaving the foundry, clean castings and apply 16-mil dry film thickness coating of coal-tar epoxy, unless otherwise specified or indicated on the Drawings.
3. Miscellaneous Stainless Steel:
 - a. Provide miscellaneous stainless steel items not specified herein as indicated on the Drawings or specified elsewhere. Fabricate and install in accordance with the best practices of the trade.
4. Miscellaneous Structural Steel:
 - a. Provide miscellaneous steel items not specified herein as indicated on the Drawings or specified elsewhere. Fabricate and install in accordance with the best practices of the trade.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verification of Conditions: Examine work in place to verify that it is satisfactory to receive the work of this Section. If unsatisfactory conditions exist, do not begin this work until such conditions have been corrected.

3.02 INSTALLATION

- A. General: Install products as indicated on the Drawings, and in accordance with shop drawings and manufacturer's printed instructions, as applicable except where specified otherwise.
- B. Aluminum Stair Nosing:

1. Install stair nosings on treads of concrete stairs, including top tread on upper concrete slab.
2. Omit stair nosings where concrete is submerged.
3. Coat aluminum surfaces in contact with concrete as specified in Section 09902.
4. Cast stair nosings in fresh concrete, flush with tread and riser faces. Install nosing in center of step approximately 3 inches from each stair edge.

C. Ladders:

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

D. Metal Gratings:

1. General:
 - a. Allow 1/8-inch maximum clearance between ends of grating and inside face of vertical leg of shelf angles.
 - b. Horizontal bearing leg of shelf angles shall be 2 inches minimum.
 - c. Install metal plate or angles where necessary to fill openings at changes in elevation and at openings between equipment and grating.
 - d. Install angle stops at ends of grating.
 - e. Installed grating shall not slide out of rebate or off support.
 - f. Weld stops in place, unless otherwise specified or indicated on the Drawings.
 - g. Top surfaces of grating sections adjacent to each other shall lie in same plane.
2. Aluminum Grating:
 - a. Coat surfaces of aluminum shelf angles, rebates, and rod anchors in contact with concrete as specified in Section 09902.
 - b. Aluminum Grating: Support on aluminum shelf angles or rebates.
3. Steel Grating:
 - a. Support on hot-dip galvanized structural steel shelf angles or rebates.
4. Heavy-Duty Steel Grating:
 - a. Support on hot-dip galvanized structural steel rebates embedded and anchored in concrete.
 - b. Use for roadways, traffic areas, and where indicated on the Drawings.

E. Stairs:

1. General:
 - a. Install guard railings around stair wells as indicated on the Drawings or specified.

3.11 MEASUREMENT AND PAYMENT

No separate measurement and payment for work performed under this Section. Include cost of same in Contract price bid for work of which this is a component part.

END OF SECTION

SECTION 05511
METAL STAIRS

PART 1 GENERAL

1.01 SUMMARY

- A. Furnish all labor, materials, equipment and incidentals required and design, fabricate and install metal pan type stairs as shown on the Drawings and as specified herein.

1.02 RELATED REQUIREMENTS

- A. Concrete fill and welded wire fabric reinforcing for stair treads and platforms is included in Section 403S.
- B. Structural steel is included in Section 05120.
- C. Handrailings attached to walls and not attached to stair structure are included in Section 05520.
- D. Guardrails and handrails are included in Section 05520.
- E. Grating is included in Division 5.
- F. Field painting is included in Section 09902.

1.03 REFERENCES

- A. American Society for Testing and Materials (ASTM)
 - 1. ASTM A36 - Standard Specification for Carbon Structural Steel.
 - 2. ASTM A48 - Standard Specification for Gray Iron Castings.
 - 3. ASTM A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
 - 4. ASTM A500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
 - 5. ASTM A 992 - Standard Specification for Structural Steel Shapes.
- B. American Institute of Steel Construction (AISC)
 - 1. AISC S326 - Specification for the Design, Fabrication and Erection of Structural Steel for Buildings
- C. American Welding Society (AWS)
 - 1. AWS D1.1 - Structural Welding Code Steel.
- D. National Association of Architectural Metal Manufacturers (NAAMM)

1. Metal Stairs Manual.

E. Occupational Safety and Health Administration (OSHA)

F. International Building Code (IBC)

G. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.04 SYSTEM DESCRIPTION

A. Fabricated metal pan stairs with concrete-filled treads and intermediate landings and steel pipe railings. Galvanized steel throughout for interior and exterior locations.

1.05 SUBMITTALS

A. Furnish the following in accordance with Specification Section 01300, "Submittals" and Section 01730, "Operation and Maintenance Data".

B. Submit, shop drawings showing clearly the location, size and details of all members, including length and size of all shop and field welds. Each field piece shall be plainly marked with suitable erection marks which shall also be shown on the erection diagram. Shop drawings shall show erection details and welding conditions.

C. Submit for review, structural calculations for the stair system, signed and sealed by a licensed professional engineer registered in the State of Texas.

1.06 QUALITY ASSURANCE

A. Industry Standards: Comply with the provisions of the following standards:

1. AISC S326

2. NAAMM - AMP-510

3. AWS D1.1.

1.07 DELIVERY, STORAGE AND HANDLING

A. All materials shall be delivered promptly so as to cause no delay with other parts of the work. Stored materials shall be placed on skids and not on the ground and shall be piled and blocked up so that they will not become bent or otherwise damaged. Materials shall be handled with cranes or derricks as far as practicable. Material shall not be dumped off cars or trucks nor handled in any other way likely to cause damage. Materials with excessive damage, in the opinion of the Engineer, shall not be incorporated in the work and shall be removed and replaced with new undamaged materials by the Contractor at no expense to the Owner.

1.08 WARRANTY

A. Section 01700 – Contract Closeout: Product warranties and product bonds.

- B. For warranty repair work, remove and replace materials as needed.

PART 2 PRODUCTS

2.01 DESIGN CRITERIA

- A. Stairs and handrailings shall conform to the Uniform Building Code and OSHA Standards for occupancy indicated on the drawings.
- B. Design stair assembly to support a minimum live load of 100 lbs/sq ft. Refer to Section 05500 Metal Fabrications for minimum design live load requirements for grating.
- C. Design handrails and railings to meet Uniform Building Code and OSHA Standards and to withstand 200 lbs load applied anywhere on the system and in any direction.

2.02 MATERIALS

- A. Metal Surfaces: For fabrication of metal stair work which will be exposed to view, use only materials which are smooth and free of surface blemishes including pitting, seam marks, roller marks, rolled trade names and roughness. Remove blemishes by grinding and/or welding and grinding prior to cleaning, treating and application of surface finishes.
- B. Structural Steel Plates, Shapes and Bars: ASTM A36.
- C. Aluminum Extruded Bar and Shapes, Extruded Tube and Pipe: Alloy 6063-T6
- D. Aluminum Extruded Structural Shapes, Tread Plate for Platforms: Alloy 6061-T6
- E. Aluminum Tread Plate for Treads: Alloy 6061-T4
- F. Hot-Rolled Carbon Steel Sheets and Strips: ASTM A570.
- G. Steel Tube/Pipe: ASTM A53, Type S, Grade A and ASTM A500A.
- H. Malleable Iron Castings: ASTM A48, Class 30.
- I. Shop Primer Paint: Prepare surfaces and epoxy prime as approved, compatible with finish paint specified. Comply with requirements of Section 09901.
- J. Aluminum Handrails and Guardrails: 6361 T6 alloy/temper with fasteners and appurtenances, all as specified in Section 05520.
- K. Safety nosings as specified in Section 05500 to be cast into stair pan concrete treads and landings riser nosings at all stairs.

2.03 FABRICATION

- A. Size members as required by design calculations and job conditions.
- B. Stringers and Headers: Steel channel stringers shall be clip angled to concrete walls, concrete beams, concrete slab edge, steel or aluminum headers/ledgers as indicated on the Drawings.

Stringers shall furnish support to intermediate landings, unless otherwise indicated on the Drawings.

- C. Metal Risers and Treads: Form metal risers and treads of minimum 14 gauge structural steel and minimum 12 gauge aluminum sheet metal and shop weld to stringer in an approved manner.
- D. Landings: Construct platforms of loose structural steel channels, side-supported headers and miscellaneous framing members framing into the stair stringers. Provide minimum 14 gauge landing decking complete with shop welded reinforcing rods topside and perimeter screed members.
- E. Construct stairs to conform to sizes and arrangements indicated; join pieces together by welding unless otherwise indicated. Provide complete stair assemblies including metal framing, hangers, columns, struts, clips, brackets, bearing plates and other components necessary for the support of stairs and platforms and as required to anchor and contain the stairs on the supporting structure.
- F. Fabricate stringers of structural steel or aluminum channels, or plates, or a combination thereof, as indicated on Drawings. Provide closures for exposed ends of stringers. Construct platforms of structural steel channel headers and miscellaneous framing members as indicated. Bolt or weld headers to stringers and framing members to stringers and headers. Fabricate and join so that bolts, if used, do not appear on finish surfaces.
- G. Metal pan risers, subtreads and subplatforms: Shape metal pans for risers and subtreads to conform to configuration shown. Provide thicknesses of structural steel sheet for metal pans indicated but not less than that required to support total design loading.
- H. Attach risers, subtreads and subplatforms to stringers by means of brackets made of steel angles or bars. Weld brackets to stringers and attach metal pans to brackets by welding, or bolting.
- I. Form work true to line and level with accurate angles and surfaces and straight sharp edges. Ease exposed edges to radius of approximately 1/32-in. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing work.
- J. Weld all assemblies in accordance with recommendations of AWS. Grind all exposed welds to match and blend with adjoining surfaces.

2.04 SURFACE PREPARATION AND SHOP PRIME PAINTING

- A. Remove scale, rust and other deleterious materials before applying shop primer. Prepare surfaces and apply one shop coat of metal primer to fabricated metal items as specified in Section 09901. Primer furnished and finish coats specified in Section 09902 shall be compatible.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Provide anchorage devices and fasteners where required and approved for securing steel stair items to in-place construction, including threaded fasteners for concrete inserts, toggle bolts, through-bolts and other connectors. No stair hanging allowed.
- B. Perform drilling and fitting for installation of stair work. Set work in location, alignment and elevation plumb and level, true and free of rack, measured with approved shop drawings.
- C. Plumb posts of railing in each direction. Secure posts by welding direct to stair stringers, or as otherwise shown or approved.

END OF SECTION

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SECTION 05520
ALUMINUM HANDRAILS

PART 1 GENERAL

1.01 SUMMARY

- A. This Section includes the fabrication, furnishing, and installation of aluminum handrails, complete in place, at locations shown on PLANS.

1.02 REFERENCES

- A. The publications listed below form a part of this Specification to the extent referenced. The publications are referred to in the text by basic designation only.
- B. Aluminum Association (AA):
 - 1. ASD-1 - Aluminum Standards and Data
 - 2. DAF-45 - Designation System for Aluminum Finishes
 - 3. SAA-46 - Standards for Anodized Architectural Aluminum
- C. American Society for Testing and Materials (ASTM):
 - 1. ASTM A193/A193M - Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High Temperature Service
 - 2. ASTM B429 - Standard Specification for Aluminum All Extruded Structural Pipe and Tube
 - 3. ASTM F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs
- D. American Welding Society (AWS):
 - 1. AWS D1.2 - Structural Welding Code Aluminum
- E. Occupational Safety and Health Administration (OSHA):
 - 1. 29 CFR 1910 - OSHA Regulation Safety and Health Standards for General Industry
- F. International Conference of Building Officials (ICBO)
 - 1. IBC - International Building Code (IBC)

1.03 DEFINITIONS

- A. Plans use the terms handrail and guardrail to refer to the railing system defined by this Specification and standard detail drawings.

1.04 SUBMITTALS

- A. Submit the following in accordance with Specification Section 01300, "Submittals".
 - 1. Product data for materials used.
 - 2. Complete shop drawings showing handrail locations, railings, posts, splice locations and expansion joint locations. Also include manufacturer's details for connections, anchorage, splices, expansion joints, gates and other pertinent data.
 - 3. Design calculations showing that the material meets or exceeds the allowable working stress under the applied loading conditions. Test reports may be used to complement the design calculations. Design calculations to be sealed by a Professional Engineer licensed in the State of Texas.
 - 4. Field layout of fabricated sections to ensure proper fit during erection, after fabrication and finishing, and prior to shipment.
 - 5. Certificate of Conformance as required in Paragraph 1.05 – Quality Assurance.

1.05 QUALITY ASSURANCE

- A. All design computations and detailed drawings are to be prepared by or under the direct supervision of a Professional Engineer licensed in the State of Texas. Provide a certificate signed and sealed by same engineer stating that the computations and drawings are in conformance with specified design criteria.
- B. Provide handrail system complying with International Building Code and OSHA Regulations.

1.06 DELIVERY, STORAGE AND HANDLING

- A. Deliver handrail to jobsite with sufficient protection to ensure arrival in acceptable and undamaged condition.
- B. Store handrails on level supports above ground, not in contact with dissimilar metals. Protect to prevent damage and exposure from elements until erected. Replace or repair damaged sections at no additional cost to OWNER.

PART 2 PRODUCTS

2.01 MANUFACTURER(S)

- A. Manufacturer: Products of the following manufacturers, provided they comply with requirements of the Contract Documents, will be among those considered acceptable, or an approved equal.
 - 1. Hollaender Railing Systems (Interna-Rail);
 - 2. Thompson Fabrication Co. (TUFrail); and
 - 3. Alumaguard Corp. (Alumarail).

2.02 MATERIALS AND/OR EQUIPMENT

A. General

1. Handrail shall be the product of a company normally engaged in the manufacture of pipe railing.
2. Handrail shall conform to requirements of OSHA 1910.23 and applicable building code. Local building code in Austin, TX is the International Building Code.
3. Handrail and posts to be fabricated from 1½-inch nominal diameter 6063-T6 or 6061-T6 aluminum pipe, Schedule 40 minimum conforming to ASTM B429. Exposed aluminum surface is to be 0.7-mil thick clear anodized finish, per Aluminum Association Designation M10-C22-A41.
4. Handrail to be 42 inches high; stair handrail to be 34 inches high, unless otherwise noted on PLANS. Centerlines of posts and handrails shall be in same plane. Locate intermediate rails as shown on PLANS.
5. Unless shown otherwise in PLANS, post spacing not to exceed 5 feet for horizontal handrail and 4 feet for stair handrail (measured horizontally). The manufacturer must reduce the post spacing and/or add dowels, as required to meet the loading requirements.
6. Provide a 4-inch-high extruded aluminum toe plate that attaches to the posts with clamps that will allow for horizontal expansion and contraction between posts. Toe plate to have not more than 1/4-inch clearance above floor level and provided on all walkways and stair landings. Provide notch in toe plate at post as required to maintain specified clearance.
7. Handrail system, which consists of three horizontal rail members, posts, connections and anchorages, shall be designed to withstand a 200-pound concentrated load applied at any point and in any direction or a 50 lb./ft. uniform load applied in any direction. Concentrated and uniform loads need not be assumed to act concurrently. The posts and associated floor flange anchorage shall be designed to withstand a 200-pound concentrated load applied at the top rail.
8. Provide expansion joint splices in all rails of handrail and toe board at not greater than 20 feet spacing and at expansion joints in concrete structure. Minimum projection of expansion splice inside adjacent pipe shall be 1½".
9. Splices and expansion joints in the railing system components shall be located within 8 inches of posts or other railing system supports.
10. Provide 1/4-inch weep holes at low points in all handrails and posts to prevent trapping of moisture.
11. Removable handrail to have vertical pipe supports fastened as shown on PLANS. Unless otherwise indicated, fabricate removable handrail in unit sections not exceeding 10 feet long with at least three vertical supports, including one at each end.
12. Handrails attached to load-bearing walls to be mounted with aluminum or stainless steel brackets. Fasten each bracket with a minimum 3/8-inch diameter Type 316 stainless steel

expansion bolt set into the wall and tapped into bracket. Bracket to have a 3-inch projection from wall and be uniformly spaced approximately 4 feet with the end brackets not more than 12 inches from the ends of the handrails.

13. Posts and rails to be continuous throughout their sectional lengths. Curved members shall be formed to true radii, free from dye marks or surface abrasions. Furnish handrail in shop fabricated sections, complete with accessories, including gates, hardware, closure caps for rail terminations, base trim, and anchorages.
14. Posts shall not interrupt the continuation of the top rail at any point along the railing, including corners and end terminations (OSHA 1910.23). The top surface of the top railing shall be smooth and shall not be interrupted by a projecting fitting.
15. Aluminum surfaces in contact with concrete, grout or dissimilar metals will be protected with a mylar isolator, bituminous paint or other approved material.
16. Handrail system posts are to be anchored to concrete structures with Type 316 stainless steel bolts. Bolts and floor flange shall be designed to resist a 200-pound load applied horizontally to the top rail. Bolt manufacturer's published shear and pullout values shall be reduced for spacing and edge distance conditions as shown on plans.
17. Safety Chains: Construct safety chains of stainless steel, straight link type, 3/16-inch diameter, with at least twelve links per foot, and with boat type snap hooks on each end. Provide S.S. 3/8-inch bolt with 3/4 -inch eye diameter for attachment of chain, anchored as indicated. Supply a minimum of two chains or as noted on PLANS, 4 inches longer than the anchorage spacing, for each guarded area. Locate safety chain where indicated.

B. Non-welded Aluminum Handrails

1. Fittings to be extruded or cast aluminum, 6063 Aluminum Alloy with a minimum 0.4-mil thick clear anodized finish per Aluminum Association Designation M43C22A41.
2. The handrail shall be made of pipes joined together with component fittings. Components that are glued or pop-riveted at the joints will not be acceptable. All components must be mechanically fastened with stainless steel hardware.
3. Fitting shall be an internal double-prong expandable fitting that is activated by a stainless steel or aluminum set screw. The fitting shall be externally connected to the pipe by means of an anodized aluminum tubular rivet nut, and stainless steel socket head cap screw. All fittings, elbows, wall returns, and caps to be flush-type. Exposed fasteners are to be set flush or recessed. All fasteners shall be Type 316 stainless steel.
4. Unless otherwise noted on PLANS, all handrails to be non-welded aluminum.

C. Welded Aluminum Handrail

1. Handrail and posts to be joined by welding only if indicated on PLANS. Welding to consist of flush-type weld fittings or coping of pipe ends to conform with adjoining pipe and welding. Welds shall be ground smooth and flush.

2. Elbows, capped terminations, and wall returns to be formed by flush fittings. Secure rails terminating against masonry or concrete with flanged fittings and anchor bolts.

2.03 FABRICATION

- A. Furnish railings in shop-fabricated sections, complete with accessories, including gates, plated hardware, closure caps for rail termination, base trim, and anchorages.

PART 3 EXECUTION

3.01 ERECTION/INSTALLATION/APPLICATION AND/OR CONSTRUCTION

- A. Handrail to be installed by fabricator in strict compliance with fabricator's instructions. Install handrail plumb and within a tolerance of 1/4-inch maximum deviation either side of the longitudinal centerline. Cuts shall be clean and straight, free from burrs and nicks.
- B. Posts embedded in concrete to be set in sleeves with quick-setting non-shrink grout.
- C. Install removable and permanent handrail units with bolted floor type flanges.
- D. Use of shims, washers, wedges, or similar devices are not allowed when plumbing or aligning handrail.

3.02 MEASUREMENT AND PAYMENT

- A. No separate measurement or payment for work performed under this Section. Include cost of same in Contract price bid for work of which this is a component part.

END OF SECTION

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SECTION 08220
FIBERGLASS REINFORCED PLASTIC DOORS AND FRAMES

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. Furnish all labor, materials, equipment, and incidentals required and deliver fiberglass reinforced plastic (FRP) doors and frames, fire rated FRP door and gel coated steel door and window frames, with appurtenances as shown, as scheduled, and as herein specified.

1.02 SUBMITTALS

- A. Submit, in accordance with Section 01300, complete shop drawings, working drawings, and product data for all materials furnished under this Section.
 - 1. Shop drawings shall show elevations and details of each frame type, schedule of doors and frames, door elevations and details, conditions at openings with various wall thicknesses and materials, locations and installation requirements for hardware, thickness of materials, joints and connections, and trim.
- B. Hardware templates shall be furnished to the door manufacturer by the Contractor for correct hardware alignment and reinforcing.
- C. Submit the following photos of fire rated and non-rated doors and frames for review. Photos shall show gauges, configuration, construction and finish proposed for the various components.
 - 1. Corner construction of doors: 6-inches by 6-inches.
 - 2. Door frame corner: 6-inch legs showing construction and finish.
- D. Provide certification as follows:
 - 3. Provide certification as approved that all materials, construction requirements herein specified will be met in the project.
 - 4. If required by the Engineer, provide independent laboratory testing.
- E. Operation and Maintenance Data: Include methods for maintaining installed products and precautions against cleaning materials and methods detrimental to finishes and performance.

1.03 QUALITY ASSURANCE

- A. Provide FRP components manufactured by a single firm specializing in this type of work, unless otherwise acceptable to the Engineer.

1.04 DELIVERY, STORAGE AND HANDLING

- A. All doors and frames shall be shipped with trim and all necessary items which may be required for final installation.

- B. All materials shall be delivered to the site in sealed, undamaged containers fully identified with manufacturer's name, brand, style, pattern, and color. Upon delivery to job site, materials shall be stored in original cartons, on end in such a way to prevent falling or damage to face, corners, or edges.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. FRP components shall be by Special-Lite, Corrim Doors; equal by ChemPruf (with flanged frames) or equal.

2.02 NON-RATED OPENINGS

A. Door

1. Face Sheets: Seamless fiberglass reinforced polyester plastic, 0.120-inch thick.
2. Internal Stiles and Rails: Structural fiberglass reinforced plastic with solid polymer corner reinforcement.
3. Core-Polyurethane: 1-3/4-inches thick, U factor - 0.14. For rated doors use mineral core for 1/2-hour to 1-1/2-inches rating.
4. Hardware Reinforcement: Solid polymer.
5. Intermediate Framing: Supply structural FRP as and where required for door integrity.
6. Chemically weld entire door.
7. Polyester gel-coat entire door following hardware machining, 15 mils plus/minus 3 mils, dry film thickness.

B. Frame

1. Closely match hollow metal frames: 5-3/4-inches wide by 2-inches deep with a hollow door stop.
2. Reinforcement: Solid polymer according to templates provided by the hardware supplier.
3. Rabbet: 1-15/16-inches.
4. Miter corner 45 degrees, fabricated for knock down assembly.

C. Vision Panel Trim

1. Polymer (PVC) vision panel trim for 1/4-inch thick glass.
2. Provide factory fabricated for field installation.

D. Color - Gel Coat

1. Frame: To match specified color for aluminum frames (bronze).
2. Door: To match specified color for aluminum doors (bronze).

E. Anchors

1. Fiberglass reinforced T-anchors, similar to those used in hollow metal door construction, shall be used to fasten frames to new masonry.
2. Stainless steel fasteners, 300 Series as approved, shall be used for frame assembly and for all other fasteners.

2.03 FIRE RATED OPENINGS

- A. Door: As specified above except provide mineral core, fire retardant pultruded internal FRP stiles and rails and factory installed intumescent seals recessed into edges of doors, around perimeter, all as tested and approved by UL. Provide UL label permanently fixed to hinge edge, coordinated with placement of intumescent strip. Door rating in hours shall be equal to or greater than rating required by Door Schedule.
- B. Frame: Welded construction, 14 gauge galvanized steel and with UL affixed for a frame rating in hours equal to or greater than rating required by Door Schedule. Provide with three minimum and 2-feet-6-inches maximum on center placement, UL approved jamb anchors for building into masonry walls as they are constructed. Grout frames fully when in place. Frame: Factory gel coat on properly prepared steel, all surfaces, inside and out, except bonding surfaces of anchors. Gel coat shall be as specified for doors.
- C. Provide fire rated steel window frame where scheduled with UL label, two UL anchors per jamb, steel glazing beads and gel coated, all as specified above for fire rated door frames.

PART 3 EXECUTION

3.01 INSTALLATION

- A. All frames and fittings shall be installed and adjusted in strict accordance with the recommendations of the manufacturer and shop drawings.
- B. Screws, nuts, washers, bolts, and other miscellaneous fastening devices for hardware shall be as shown and specified in the Contract Documents.

END OF SECTION

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SECTION 09850
CORROSION PROTECTION FOR CONCRETE STRUCTURES

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. This specification covers work, materials and equipment required for protecting the interior of concrete structures by spray-application of a 100 percent solids and VOC-free coating system to provide corrosion protection (protective coating). Procedures for surface preparation, cleaning, application and testing are described herein.
- B. Provide a protective coating for the following:
 - 1. Walls and underside of the concrete top of the thickener supernatant box and the scum pump wet well at each gravity thickener.
 - 2. Launder surfaces at each gravity thickener as shown on process mechanical drawings.
 - 3. Any other surfaces as indicated on the Drawings or specified herein.

1.02 RELATED SECTIONS

- A. Section 403S – Concrete for Structures.
- B. Section 410S – Concrete Structures.

1.03 REFERENCES

- A. ASTM D638 - Tensile Properties of Plastics.
- B. ASTM D790 - Flexural Properties of Unreinforced and Reinforced Plastics.
- C. ASTM D695 - Compressive Properties of Rigid Plastics.
- D. ASTM D4541 - Pull-off Strength of Coatings Using a Portable Adhesion Tester.
- E. ASTM D2584 - Volatile Matter Content.
- F. ASTM D2240 - Durometer Hardness, Type D.
- G. ASTM D543 - Resistance of Plastics to Chemical Reagents.
- H. ASTM C109 - Compressive Strength Hydraulic Cement Mortars.
- I. ASTM - The published standards of the American Society for Testing and Materials, West Conshohocken, PA.
- J. NACE - The published standards of National Association of Corrosion Engineers (NACE International), Houston, TX.

- K. SSPC - The published standards of the Society of Protective Coatings, Pittsburgh, PA.
- L. SSPWC 210-2.3.3 - Chemical resistance testing published in the Standard Specifications for Public Works Construction, 1997 edition (otherwise known as "The Greenbook").

1.04 SUBMITTALS

- A. The following items shall be submitted:
 - 1. Technical data sheet on each product used, including ASTM test results indicating the product conforms to and is suitable for its intended use per these specifications.
 - 2. Material Safety Data Sheets (MSDS) for each product used.
 - 3. Project specific guidelines and recommendations.
 - 4. Applicator Qualifications:
 - a. Manufacturer certification that Applicator has been trained and approved in the handling, mixing and application of the products to be used.
 - b. Certification that the equipment to be used for applying the products has been manufactured or approved by the protective coating manufacturer and Applicator personnel have been trained and certified for proper use of the equipment.
 - c. Three (3) years of experience and five (5) recent references of projects of similar size and scope and Applicator must provide references indicating successful application on underground concrete or masonry substrates of a minimum 100,000 sf of the specified 100% solids, VOC-free protective coating by plural component spray application.
 - d. Proof of any required federal, state or local permits or licenses necessary for the project.

1.05 QUALITY ASSURANCE

- A. Applicator shall initiate and enforce quality control procedures consistent with applicable ASTM, NACE and SSPC standards and the protective coating manufacturer's recommendations.
- B. A NACE certified coating inspector ("Inspector") shall be provided by Owner. The Inspector will observe surface preparation, application and material handling procedures to ensure adherence to the specifications.

1.06 STORAGE AND HANDLING

- A. Products are to be kept dry, protected from weather and stored under cover.
- B. Products are to be stored and handled according to their material safety data sheets.

1.07 SITE CONDITIONS

- A. Applicator shall conform with all local, state and federal regulations including those set forth by OSHA, RCRA and the EPA and any other applicable authorities.

1.08 WARRANTY

- A. Applicator shall warrant all work against defects in materials and workmanship for a period of five (5) year, unless otherwise noted, from the date of final acceptance of the project. Applicator shall, within a reasonable time after receipt of written notice thereof, repair defects in materials or workmanship which may develop during said five (5) year period, and any damage to other work caused by such defects or the repairing of same, at his own expense and without cost to the Owner.
- B. Applicator shall warrant the protective coating against (a) delamination from substrate; (b) degradation of finish; (c) cracking and spalling of finish; (d) corrosion of substrate due to defects in finish; (e) where defects in workmanship create a failure as defined in 1.08D, the warranty against failure shall apply.
- C. "Failure" will be deemed to have occurred if the protective lining fails to (a) prevent the internal damage or corrosion of the structure (b) protects the substrate and environment from contamination by wastewater contents (both liquid and gaseous). If any such failure occurs within the five (5) years from the date of the Owner's acceptance of the project, the damage shall be repaired to restore the lining to like new condition at no cost to the Owner within 60 days after written notification of the failure. "Failure" does not include damage resulting from mechanical force not customarily present or act of God.
- D. A warranty inspection shall be conducted annually for the entire warranty period with the manufacturer present. The manufacturer shall conduct the warranty inspection in the presence of the Owner. The manufacturer shall produce a written report within two weeks of the inspection and must include the Owner's signature. Any defective work discovered shall be corrected by the Contractor in accordance with specifications and at no additional cost to the Owner. Other corrective measures may be required during the warranty period.

PART 2 PRODUCTS

2.01 EXISTING PRODUCTS

- A. Standard Portland cement or new concrete (not quick setting high strength cement) must be well cured prior to application of the protective coating.

2.02 PROTECTIVE COATING MANUFACTURER

- A. Raven Lining Systems, Inc., Tulsa, Oklahoma.
- B. Sprayroq, Inc., Pelham, Alabama.
- C. Quadex, North Little Rock, Arkansas.
- D. Sealing Systems, Loretto, MN

2.03 PROTECTIVE COATING

- A. Refer to City of Austin SPL No. WW-511 for specified products by specified manufacturers listed in 2.02.

2.04 PROTECTIVE COATING APPLICATION EQUIPMENT

- A. Manufacturer approved plural component spray equipment shall be used in the application of the specified protective coating.

PART 3 EXECUTION

3.01 ACCEPTABLE APPLICATORS

- A. Protective coating must be applied by a Certified Applicator of the protective coating manufacturer and according to manufacturer specifications.

3.02 EXAMINATION

- A. All structures to be coated shall be readily accessible to Applicator.
- B. Appropriate actions shall be taken to comply with local, state and federal regulatory and other applicable agencies with regard to environment, health and safety.
- C. Any active flows shall be dammed, plugged or diverted as required to ensure that the liquid flow is maintained below the surfaces to be coated. Flows should be totally plugged and/or diverted when coating the invert. All extraneous flows into the concrete structure at or above the area coated shall be plugged and/or diverted until the coating has set hard to the touch.
- D. Installation of the protective coating shall not commence until the concrete substrate has properly cured in accordance with these specifications.
- E. Temperature of the surface to be coated should be maintained between 40 deg F and 120 deg F during application. Prior to and during application, care should be taken to avoid exposure of direct sunlight or other intense heat source to the structure being coated.

3.03 SURFACE PREPARATION

- A. Applicator shall inspect all specified surfaces prior to surface preparation. Applicator shall notify Owner of any noticeable disparity in the surfaces which may interfere with the proper preparation or application of the protective coating.
- B. Applicator shall perform all surface preparation and protective coating installation.
- C. All contaminants including: oils, grease, incompatible existing coatings, waxes, form release, curing compounds, efflorescence, sealers, salts, or other contaminants shall be removed. All concrete or mortar that is not sound or has been damaged by chemical exposure shall be removed to a sound concrete surface or replaced.
- D. Surface preparation method(s) should be based upon the conditions of the substrate, service environment and the requirements of the protective coating to be applied. Surfaces to receive protective coating shall be cleaned and abraded to produce a sound surface with adequate profile and porosity to provide a strong bond between the protective coating and the substrate.
- E. All surfaces should be inspected by the Inspector during and after preparation and before the protective coating is applied.

3.04 APPLICATION OF PROTECTIVE COATING

- A. Application procedures shall conform to the recommendations of the protective coating manufacturer, including material handling, mixing, environmental controls during application, safety, and spray equipment.
- B. The spray equipment shall be specifically designed to accurately ratio and apply the specified protective coating materials and shall be regularly maintained and in proper working order.
- C. The protective coating material must be spray applied by a Certified Applicator of the protective coating manufacturer.
- D. Specified surfaces shall be coated by spray application of a moisture tolerant, VOC-free, 100% solids, protective coating at a thickness as specified in SPL No. WW-511.
- E. If necessary, subsequent topcoating or additional coats of the protective coating should occur as soon as the basecoat becomes tack free, (normally within 2-4 hours) but no later than the recoat window (normally 24 hours at 70° F) for the specified products. Additional surface preparation procedures per Manufacturer's recommended specifications will be required if this recoat window is exceeded.

3.05 TESTING AND INSPECTION

- A. During application, Applicator shall regularly perform and record protective coating thickness readings with a wet film thickness gage meeting ASTM D4414 - Standard Practice for Measurement of Wet Film Thickness of Organic Coatings by Notched Gages, to ensure a uniform thickness during application. A minimum of three readings per 200 square foot area shall be recorded. Applicator will submit all documentation on thickness readings to Inspector on a daily basis when coating application occurs.
- B. Applicator shall perform holiday detection on all surfaces coated with the protective coating in the presence of Inspector. After the protective coating has set hard to the touch, surfaces shall first be dried, an induced holiday shall then be made on to the coated concrete surface and shall serve to determine the minimum/maximum voltage to be used to test the coating for holidays at that particular area. The spark tester shall be initially set at 100 volts per 1 mil (25 microns) of film thickness applied but may be adjusted as necessary to detect the induced holiday (refer to NACE RPO188-99). All detected holidays shall be marked and repaired by abrading the coating surface with grit disk paper or other hand tooling method. After abrading and cleaning, additional protective coating material can be hand applied to the repair area. All touch-up/repair procedures shall follow the protective coating manufacturer's recommendations. (Note: This procedure is sometimes difficult or impossible to perform in tight manhole or vault structures or may provide unreliable readings when testing coatings applied to concrete.)
- C. Measurement of bond strength of the protective coating to the substrate shall be made at regular intervals and along different sections of the structure. At the sole discretion of the Project Engineer, a minimum of three (3) successful pull test evaluations (glue failure constitutes an unsuccessful pull) shall be made every 1,000 square feet of coated structure. Bond strength shall be measured in accordance with ASTM D4541. Any areas detected to have inadequate bond strength shall be evaluated by the Project Engineer. Further bond tests may be performed

in that area to determine the extent of potentially deficient bonded area and repairs shall be made by Applicator in strict accordance with manufacturer's recommendations.

- D. A final visual inspection shall be made by the Inspector and Applicator. Any deficiencies in the finished coating shall be marked and repaired by Applicator according to the procedures set forth herein.

3.06 FIELD QUALITY CONTROL

- A. Certified manufacturer's representative shall be present to observe application of coating and after completion to inspect and certify that product was properly applied.
- B. Random areas shall be sound tested in the presence of the Owner's Representative, where coating has been applied in accordance with manufacturer recommendations.

3.07 CLEAN AND ADJUST

- A. Promptly remove trash and debris resulting from coating operation from the site.
- B. Use commercial solvents to clean tools immediately after use. Once cured, the material must be mechanically abraded.

END OF SECTION

SECTION 09901
SURFACE PREPARATION AND SHOP PRIME PAINTING

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. Furnish all labor, materials, equipment and incidentals required for the surface preparation and application of shop primers on ferrous metals, excluding stainless steels, as specified herein.

1.02 RELATED WORK

- A. Finish painting is included in Section 09902.

1.03 SUBMITTALS

- A. Submit, in accordance with Section 01300, shop drawings, manufacturer's specifications and data on the proposed primers and detailed surface preparation, application procedures and dry mil thicknesses.
- B. Submit representative physical samples of the proposed primers, if required by the Engineer.

1.04 REFERENCE STANDARDS

- A. The Society for Protective Coatings (SSPC).
 - 1. SSPC-SP 6/NACE No. 3 - Joint Surface Preparation Standard SSPC-SP 6/NACE No. 3: Commercial Blast Cleaning.
 - 2. SSPC-SP 10/NACE No. 2 - Joint Surface Preparation Standard SSPC-SP 10/NACE No. 2: Near-White Blast Cleaning.
- B. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Submerged Surfaces - Shop primer for ferrous metals which will be in contact with water being treated, either submerged or which are subject to splash action or which are specified to be considered submerged service shall be shop primed with the following:
 - 1. Shop Prime Coat: (Zinc Micaceous Iron Oxide Polyurethane Aromatic Shop Primer)
 - a. TNEMEC: Series 1 Omnithane
 - b. Carboline: Carboguard 561
 - c. Sherwin-Williams Company (The): Corothane I Zinc Primer 1K Mio-Zinc
 - d. PPG PMC Durathane MCZ 97-679 Series or PPG PMC Amerlock 400
 - e. Or equal

- B. Non-Submerged Surfaces: Shop primer for ferrous metals which will not be in contact with water being treated, not submerged and not subject to splash action shall be shop primed with the following:
1. Shop Prime Coat: (Zinc Micaceous Iron Oxide Polyurethane Aromatic Shop Primer)
 - a. TNEMEC: Series 1 Omnithane
 - b. Carboline: Carboguard 561
 - c. Sherwin-Williams Company (The): Corothane I Zinc Primer 1K Mio-Zinc
 - d. PPG PMC Durathane MCZ 97-679 Series or PPG PMC Amercoat 68HS
 - e. Or equal
- C. Submerged Surfaces:
1. Shop Prime Coat for Ductile Iron Pipe: (Epoxy, Polyamidoamine Shop Primer)
 - a. TNEMEC: Series N140 Pota-Pox-Plus
 - b. Carboline: Carboguard 561
 - c. Sherwin-Williams Company (The): Macropoxy 846 NSF Winter Grade Epoxy Mill White
 - d. PPG PMC Aquapon HB Potable Water Epoxy Coating 95-132 Series or PPG PMC Amerlock 2 Epoxy
 - e. Or equal
 2. Shop Prime Coat for Ferrous Metal Surfaces: (Zinc Micaceous Iron Oxide Polyurethane Aromatic Shop Primer)
 - a. TNEMEC: Series 1 Omnithane
 - b. Carboline: Carboguard 561
 - c. Sherwin-Williams Company (The): Corothane I Zinc Primer 1K Mio-Zinc
 - d. PPG PMC Durathane MCZ 97-679 Series
 - e. Or equal
- D. Non-Primed Surfaces - Gears, bearings surfaces and other similar surfaces obviously not to be painted shall be given a heavy shop coat of grease or other suitable rust-resistant coating. This coating shall be maintained as necessary to prevent corrosion during all periods of storage and erection and shall be satisfactory to the Engineer up to the time of the final acceptance test.
- E. Compatibility of Coating Systems - Shop priming shall be done with primers that are guaranteed by the manufacturer to be compatible with their corresponding primers and finish coats specified in Section 09902 for use in the field and which are recommended for use together.

PART 3 EXECUTION

3.01 APPLICATION

A. Surface Preparation and Priming

1. Non-submerged components scheduled for priming, as defined above, shall be blast cleaned in accordance with SSPC-SP 6/NACE No. 3, immediately prior to priming. Submerged components scheduled for priming, as defined above, shall be blast cleaned in accordance with SSPC-SP 10/NACE No. 2, immediately prior to priming. Consult manufacturer regarding required surface profiles.

2. Surfaces shall be dry and free of dust, oil, grease and other foreign material before priming.
3. Shop prime in accordance with approved manufacturer's recommendations.

B. Non-Primed Surfaces

1. Apply approved coating per manufacturer's recommendations.

3.02 FABRICATED ITEMS

- A. All items to be shop primed shall be blast cleaned as specified for applicable service prior to priming. If, in the opinion of the Engineer, any prime coating that has been improperly applied or if material contrary to this Section has been used, that coating shall be removed by abrasive blasting to white metal and reprimed in accordance with this Section.
- B. All shop prime coats shall be of the correct materials and applied in accordance with this Section. Remove any prime coats not in accordance with this Section by blast cleaning and apply the specified prime coat at no additional cost to the Owner.
- C. Shop primed surfaces shall be cleaned thoroughly and damaged or bare spots prepared as approved and retouched with the specified primer before the application of successive paint coats in the field.
- D. Shop finish coats, if proposed and allowed, shall be equal in appearance and protection quality to a field applied finish coat. If, in the opinion of the Engineer, a shop finish coat system does not give the appearance and protection quality of other work of similar nature, prepare the surfaces and apply the coat or coats of paint as directed by the Engineer to accomplish the desired appearance and protection quality. Submit to the Engineer substantial evidence that the standard finish is compatible with the specified finish coat.
- E. Properly protect the shop prime and finish coats against damage from weather or any other cause.
- F. Wherever fabricated equipment is required to be blast cleaned, protect all motors, drives, bearings, gears, etc., from the entry of grit. Equipment found to contain grit shall be promptly and thoroughly cleaned.

END OF SECTION

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SECTION 09902
PAINTING

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. The work of this section consists of furnishing all materials, labor, equipment, and incidentals required and performing all the painting necessary to complete this Contract in its entirety, including surface preparation.
- B. It is the intent of these Specifications to paint all interior concrete where scheduled, exposed miscellaneous metal, pipe, fittings, supports, valves, equipment, and all other work obviously required to be painted unless otherwise specified. Minor items omitted in the schedule of work shall be included in the work of this Section where they come within the general intent of the specifications as stated herein.
- C. In addition to the new structures, all existing structures (piping, fittings, valves, equipment, etc.) modified in this project are to be prepared for painting and painted. This includes all items in these existing areas - exterior, interior and submerged. The paint systems to be used on all existing surfaces are as scheduled for the new structures. All pipes are to be painted to conform to the Pipe Color Schedule in Section 15120. Colors are to be consistent throughout the new and existing structures. Surface preparation shall conform to Section 09901.
- D. The following surfaces or items are not required to be painted:
 - 1. Portions of metal, other than aluminum, embedded in concrete. This does not apply to the back Aluminum to be embedded in or in contact with concrete or masonry shall be coated to prevent electrolysis.
 - 2. Stainless steel.
 - 3. Fencing.
 - 4. Concealed surfaces of pipe or crawl spaces.
 - 5. Acoustical ceilings.
 - 6. Tile.
 - 7. Exterior concrete, unless otherwise specified, and heavy duty concrete topping.
 - 8. Finish hardware, except door closers that are not finished.
 - 9. Manhole frames and covers.
 - 10. Fiberglass other than piping.
 - 11. Packing glands and other adjustable parts, and nameplates and data plates of mechanical equipment.

1.02 RELATED WORK

- A. Surface Preparation and Shop Prime Painting is included in Section 09901.
- B. Color Coding for piping is included in Section 15120.

1.03 REFERENCES

- A. American Association of State Highway and Transportation Officials (AASHTO).
- B. American Society for Testing and Materials (ASTM).
 - 1. ASTM C150 - Specification for Portland Cement.
 - 2. ASTM D4258 - Practice for Surface Cleaning Concrete for Coating.
- C. National Science Foundation (NSF).
 - 1. Standard 61.
- D. Occupational Safety and Health Act (OSHA).
 - 1. Air Pollution Control Rules.
 - 2. Color Coding.
- E. Steel Structures Painting Council (SSPC).
 - 1. SSPC-SP-1 - Surface Preparation Specification - Solvent Cleaning.
 - 2. SSPC-SP-2 - Surface Preparation Specification - Hand Tool Cleaning.
 - 3. SSPC-SP-3 - Surface Preparation Specification - Power Tool Cleaning.
 - 4. SSPC-SP-6 - Commercial Blast Cleaning.
 - 5. SSPC-SP-10 - Near White Metal Blast Cleaning.

1.04 SUBMITTALS

- A. Submit to the Engineer for review in accordance with Section 01300 shop drawings, working drawings, and product data including manufacturer's specifications and data on the proposed paint systems and detailed surface preparation, application procedures and dry film thickness. Certify that the systems submitted meet all applicable volatile organic carbon regulations. Equivalent systems are to be submitted at no additional costs to meet any new regulations.
- B. Submit to the Engineer for review in accordance with Section 01300 color cards, including standard and special colors, for initial color selections.
- C. Schedule of Painting Operations: Submit to the Engineer for review a complete Schedule of Painting Operations within 90 days after the Notice to Proceed. This Schedule is imperative so

that the various fabricators may be notified of the proper shop prime coat to apply. Properly notify and coordinate the fabricators' surface preparation and painting operations with these Specifications. This Schedule shall include for each surface to be painted, the brand name, the percent volume of solids, the coverage and the number of coats the Contractor proposes to use in order to achieve the specified dry film thickness, and color charts. When the Schedule has been approved, apply all material in strict accordance with the approved Schedule and the manufacturer's instructions. Wet and dry paint film gauges shall be made available to the Engineer to verify the proper application while work is in progress.

1.05 SPARE MATERIAL

- A. Furnish one unopened gallon can of each type and each color of paint used.

1.06 PRE-PAINTING CONFERENCE

- A. Well in advance of commencement of painting operations, but after major equipment has been delivered, a pre-painting conference shall be held. All parties with an interest in the painting work shall attend, including the Contractor, the Manufacturer, the Owner, the Engineer, and the painting subcontractor. The Contractor shall contact each party and arrange the meeting.
- B. The conference shall include an inspection of the areas to be painted by all parties and a discussion of the conformance of each area with the specifications. Important issues such as environmental conditions, climate control systems, original primer, dry film thickness, and monitoring the number of coats that have been field applied shall be discussed and problems shall be resolved.
- C. A written record of the meeting shall be submitted to the Engineer.

PART 2 PRODUCTS

2.01 MATERIALS

- A. All painting materials shall be fully equal to those manufactured by the Tnemec Company Inc., Carboline Company, and Sherwin-Williams Company. The painting schedule has been prepared on the basis of Tnemec, Carboline, and Sherwin-Williams products and recommendations for applications. No brand other than those named will be considered for approval unless the brand and type of paint proposed for each item in the following schedule together with sufficient data substantiated by certified tests conducted at no expense to the Owner, to demonstrate its equality to the paint(s) named, is submitted in writing to the Engineer for approval within 30 days after the signing of the Notice to Proceed. The type and number of tests performed and information necessary for approval shall be subject to the Engineer's approval. Color availability to match those colors specified will also be considered as an important property for equality.
- B. All painting materials shall be delivered to the mixing room in unbroken containers, bearing the manufacturer's brand, date of manufacture and name. They shall be used without adulteration and mixed, thinned, and applied in strict accordance with manufacturer's directions for the applicable materials and surface and with the Engineer's approval before using.

- C. Shop priming shall be done with primers that are guaranteed by the manufacturer to be compatible with the finish paints to be used. Refer to Section 09901 for special primers.
- D. No paint containing lead will be allowed. Oil shall be pure boiled linseed oil.
- E. Work areas will be designated by the Engineer for storage and mixing of all painting materials. Materials shall be in full compliance with the requirements of pertinent codes and fire regulations. Proper containers outside of the buildings shall be provided and used for painting wastes, and no plumbing fixture shall be used for this purpose.
- F. All recommendations of the paint manufacturer in regard to the health and safety of workmen shall be followed.

2.02 PAINTING SYSTEMS

- A. All colors will be selected by the Engineer from color charts submitted by the Contractor.
- B. The following surfaces shall have the types of paint scheduled below applied at the dry film thickness (DFT) in mils per coat noted. Some colors will require an additional coat from what is listed to get the proper color coverage.
 - 1. Interior Exposed Masonry.
 - a. Tnemec.
 - 1) 1 Coat: 130-6602 Enviro-Fill @ 60-80 sq ft/gal
 - 2) 2 Coats: N69-Color Hi-Build Epoxoline (4-6 mils DFT per coat)
 - b. Carboline.
 - 1) 1 Coat: Carboguard 510 (60-80 sq ft/gal)
 - 2) 2 Coats: 890 (4-6 mils DFT per coat)
 - c. Sherwin-Williams.
 - 1) 1 Coat: Cement Plex 875 (60-90 sq ft/gal)
 - 2) 2 Coats: Macropoxy 646 FC, B58 Series (4-6 mils DFT per coat)
 - 2. Ferrous metals submerged or subject to splashing:
 - a. Tnemec.
 - 1) 2 Coats: N69-Color Hi-Build Epoxoline II (6-8 mils DFT per coat)
 - b. Carboline
 - 1) 2 Coats: 890 (6 mils DFT per coat)
 - c. Sherwin-Williams
 - 1) 2 Coats: Macropoxy 646 FC, B58 Series (4-6 mils DFT per Coat)
 - d. Refer to Section 13121 for Pre-Engineered Metal Building Structural Frame
 - 3. Exterior nonsubmerged ferrous metals:
 - a. Tnemec.
 - 1) 1 Coat: N69-Color Hi-Build Epoxoline II (4-6 mils DFT)
 - 2) 1 Coat: 73-Color Endura-Sheild (3-5 mils DFT)
 - b. Carboline
 - 1) 1 Coat: 890 (4 mils DFT)
 - 2) 1 Coat: 133 H.B. (3-4 mils DFT)
 - c. Sherwin-Williams
 - 1) 1 Coat: Macopoxy 646 FC, B58 Series (4-6 mils DFT)

- 2) 1 Coat: Hi-Solids Polyurethane, B65-300 Series (2.5 mils DFT)
4. Interior nonsubmerged ferrous metals:
 - a. Tnemec
 - 1) 2 Coats: Series N 69-Color Hi-Build Epoxoline II (4-6 mils DFT per coat)
 - b. Carboline
 - 1) 2 Coats: 890 (4-6 mils DFT per coat)
 - c. Sherwin-Williams
 - 1) 2 Coats: Macropoxy 646 FC, B58 Series (4-6 mils DFT per coat)
5. Exterior galvanized, and non-ferrous metal:
 - a. Tnemec
 - 1) 1 Coat: Series N 69-Color Hi-Build Epoxoline II (3-5 mils DFT)
 - 2) 1 Coat: 740-Color Endura-Shield (3-5 mils DFT)
 - b. Carboline
 - 1) 1 Coat: 890 (2 - 3 mils DFT)
 - 2) 1 Coat: 133 H.B. (3 - 4 mils DFT)
 - c. Sherwin-Williams.
 - 1) 1 Coat: Macropoxy 646 FC, B58 Series (4-6 mils DFT)
 - 2) 1 Coat: Hi-Solids Polyurethane, B65 – 300 Series (2.5 mils DFT)
6. Interior galvanized, and non-ferrous metals:
 - a. Tnemec
 - 1) 2 Coats: 69-Color Hi-Build Epoxoline II (2-3 mils DFT per coat)
 - b. Carboline
 - 1) 2 Coats: 890 (2-3 mils DFT per coat)
 - c. Sherwin Williams
 - 1) 2 Coats: Macropoxy 646 FC, B58 Series (4-6 mils DFT per coat)
7. Galvanized and non-ferrous metal submerged or subject to splashing:
 - a. Tnemec
 - 1) 1 Coat: N69-1211 Epoxoline II (3-5 mils DFT)
 - 2) 1 Coat: Series N 69-Color Hi-Build Epoxoline II (4-6 mils DFT)
 - b. Carboline
 - 1) 2 Coats: 890 (4-6 mils DFT per coat)
 - c. Sherwin-Williams
 - 1) 2 Coats: Macropoxy 646 FC, B58 Series (4-6 mils DFT per coat)
8. Metal surfaces exposed to temperatures above 250°F to 400°F:
 - a. Tnemec.
 - 1) 2 Coats: 39-1261SiliconeAluminum (1 – 1.5 mils DFT per coat)
 - b. Carboline
 - 1) 1 Coat: Carbozine 11 (2-3 mils DFT)
 - 2) 1 Coat: Thermaline 4900 Series (1-2 mils DFT)
 - c. Sherwin-Williams
 - 1) 2 Coats: Silver Brite B59 S11 (1.0-1.5 mils DFT per coat)

9. Insulated Pipe: (Block Insulation: Same systems only 3 coats at 2 - 3 DFT per coat)
 - a. Tnemec
 - 1) 2 Coats: 6-Color Tneme-cryl (2 - 3 mils DFT per coat)
 - b. Carboline
 - 1) 2 Coats: 3359 (3 mils DFT per coat)
 - c. Sherwin-Williams
 - 1) 2 Coats: DTM Acrylic Gloss or Semi Gloss, B66 Series (2 - 3 mils DFT per coat)

10. Aluminum in contact with dissimilar materials:
 - a. Tnemec
 - 1) 2 Coats: 69-Color Hi-Build Epoxoline (3 mils DFT per coat)
 - b. Carboline
 - 1) 2 Coats: 890 (3 mils DFT per coat)
 - c. Sherwin-Williams
 - 1) 2 Coats: Macropoxy 646 FC, B58 Series (4 - 6 mils DFT per coat)

11. Plastic Piping/Ductwork - Interior: (Sanding mandatory).
 - a. Tnemec
 - 1) 1 Coat: 69-Color Hi-Build Epoxoline II (4 - 6 mils DFT)
 - b. Carboline
 - 1) 1 Coats: 890 (4-6 mils DFT per coat)
 - c. Sherwin-Williams
 - 1) 1 Coats: Macropoxy 646 FC, B58 Series (4 - 6 mils DFT per coat)

12. Plastic Piping/Ductwork – Exterior: (Sanding mandatory)
 - a. Tnemec
 - 1) 1 Coat: Series N 69-Color Hi-Build Epoxoline II (3 – 5 mils DFT)
 - 2) 1 Coat: Series 740 Endura Shield (3 – 5 mils DFT)
 - b. Carboline
 - 1) 1 Coat: 890 (4 mils DFT)
 - 2) 1 Coat: 133 H.B. (2.5 mils DFT)
 - c. Sherwin-Williams
 - 1) 1 Coat: Macopoxy 646 FC, B58 Series (4 - 6 mils DFT)
 - 2) 1 Coat: Hi-Solids Polyurethane, B65 Series (2.5 mils DFT)

13. Ferrous Metal Piping/Ductwork exposed to temperatures above 150°F to 250°F.
 - a. Tnemec
 - 1) 2 Coats: 69-Color Hi-Build Epoxoline II (a) (6 - 8 mils DFT per coat).
 - b. Carboline
 - 1) 2 Coats: 890 (6 mils DFT per coat)
 - c. Sherwin Williams
 - 1) 2 Coats: Macropoxy 646 FC (4 – 6 mils DFT per coat)

14. Gypsum Work
 - a. Tnemec
 - 1) 1 Coat: No. 51-792 (1 DFT)
 - 2) 2 and 3 Coats: Series 6 (3 DFT)

- b. Sherwin Williams
 - 1) 1 Coat: PrepRite 200 Primer (1.1 DFT)
 - 2) 2 and 3 Coats: DTM Primer-Finish (2.5-5.0 DFT)
 - c. PPG
 - 1) 1 Coat: Speedhide 6-2 Vinyl Acrylic Drywall Primer
 - 2) 2 and 3 Coats: Pitt-tech Plus 90-1110 Series Satin DTM Acrylic
 - d. Or equal
- C. Any surfaces not specifically named in the Schedule and not specifically accepted shall be prepared, primed and painted in the manner and with materials consistent with these Specifications. The Engineer shall select which of the manufacturer's products, whether the type is indicated herein or not, shall be used for such unnamed surfaces. No extra payment shall be made for this painting.

2.03 COLOR CODING FOR PIPES AND EQUIPMENT

- A. When color coding is specified, it shall consist of color code painting and identification of all exposed conduits, trough items, and pipelines for the transport of gases, liquid, and semi-liquids including all accessories such as valves, insulated pipe coverings, fittings, junction boxes, bus bars, connectors, and all operating accessories which are integral to be whole functional mechanical pipe and electrical conduit system. Colors for piping shall be as noted in the Pipe Color Schedule in Section 15120.
- B. All hangers and pipe support floor stands shall be painted the same color and with the same paint as the pipe it supports. The system shall be painted up to but not including the flanges attached to the mechanical equipment nor the flexible conduit connected to electrical motors. When more than one pipe system is supported on the same bracket, the bracket shall be painted the same color as the adjacent wall or ceiling.
- C. All systems which are an integral part of the equipment, that is originating from the equipment and returning to the same piece of equipment, shall be painted between and up to but not including, the fixed flanges or connections on the equipment.
- D. The color code establishes, defines, and assigns a definite color for each category of pipe. Pipelines which are not specified herein shall be assigned a color by the Engineer and shall be treated as an integral part of the Contract.
- E. Banding for pipes shall be as specified in the Pipe Color Schedule. Bands shall be 2-in wide and located on each end of the pipe title, at 2-ft from the title bands, and at wall penetrations.

2.04 LETTERING OF TITLES

- A. Each pipe system shall be labeled with the name of the materials in each pipeline and alongside this an arrow indicating the direction of flow of liquids. Titles shall be as so described in attached schedule. Titles shall not be located more than 20-linear-ft apart and shall also appear directly adjacent to each side of any wall the pipeline breaches, adjacent to each side of the valve regulator, flowcheck, strainer cleanout, and all pieces of equipment.
- B. Titles shall identify the contents by complete name. Identification title locations shall be determined by the Engineer but in general they shall be placed where the view is unobstructed

and on the two lower quarters of pipe or covering where they are overhead. Title should be clearly visible from operating positions especially those adjacent to control valves.

- C. Titles on equipment shall be applied at eye level on machines where possible or at the upper most broad vertical surface of low equipment. Where more than one piece of the equipment item to be titled exists, the items shall be numbered consecutively as indicated on the mechanical drawings or as directed by the Engineer; for example, Pump No. 1, Pump No. 2, etc. Titles shall be composed and justified on the left hand side as follows:

- 1. Pump No. 1.

- D. Application of titles.

- 1. The color of the titles shall be black or white, as approved, to best contrast with the color of the pipes and equipment and shall be stencil applied.
- 2. Stencil text is to be in ALL CAPS worded exactly as shown in the Schedule. Titles are to be printed in a single line.
- 3. Letter sizes:

| Outside Diameter of Pipe or Covering (inches) | Size of Legend Letters (inches) |
|---|---------------------------------|
| $\frac{3}{4}$ to $1\frac{1}{4}$ | $\frac{1}{2}$ |
| $1\frac{1}{2}$ to 2 | $\frac{3}{4}$ |
| $2\frac{1}{2}$ to 6 | $1\frac{1}{4}$ |
| 8 to 10 | $2\frac{1}{2}$ |
| More than 10 | $3\frac{1}{2}$ |

- a. Equipment titles are to be 2-in high.

- 4. Arrow sizes. Where "a" is equal to $\frac{3}{4}$ of outside diameter of pipe or covering, the arrow shaft shall be 2 "a" long by $\frac{3}{8}$ "a" wide. The arrow head shall be an equilateral triangle with sides equal to "a". Maximum "a" dimension shall be 6-in.
- 5. When using direction arrows, point arrowhead away from pipe markers and in direction of flow. If flow can be in both directions, use a double-headed directional flow.

2.05 METAL TAGS

- A. For pipelines smaller than $\frac{3}{4}$ -in in diameter, securely fasten metal tags, $2\frac{1}{2}$ -in \times $\frac{1}{2}$ -in, of Birmingham or Stubs 17 gauge brass with lettering etched and filled with enamel. Tags shall be approved by the Engineer.

2.06 FABRICATED EQUIPMENT

- A. Unless otherwise indicated all fabricated equipment shall be shop primed and shop or field finished.

- B. All items to be shop primed shall be thoroughly cleaned of all loose material prior to priming. If, in the opinion of the Engineer, any prime coating shall have been improperly applied or if material contrary to these Specifications shall have been used, that coating shall be removed by sandblasting to white metal and reprimed in accordance with these Specifications.
- C. All shop prime coats shall be of the correct materials and applied in accordance with these Specifications. Remove any prime coats not in accordance with these Specifications by sandblasting and apply the specified prime coat at no additional cost to the Owner.
- D. Shop primed surfaces shall be cleaned thoroughly and damaged or bare spots retouched with the specified primer before the application of successive paint coats in the field.
- E. Be responsible for and take whatever steps are necessary to properly protect the shop prime and finish coats against damage from weather or any other cause.
- F. A shop finish coat shall be equal in appearance and protection quality to a field applied finish coat. If, in the opinion of the Engineer, a shop finish coat does not give the appearance and protection quality of other work of similar nature, prepare the surfaces and apply the coat or coats of paint as directed by the Engineer.
- G. Engineer to accomplish the desired appearance and protection quality. Submit to the Engineer substantial evidence that the standard finish is compatible with the specified finish coat.
- H. Wherever fabricated equipment is required to be sandblasted, protect all motors, drives, bearings, gears, etc., from the entry of grit. Any equipment found to contain grit shall be promptly and thoroughly cleaned.

PART 3 EXECUTION

3.01 PREPARATION OF SURFACES

- A. All surfaces to be painted shall be prepared as specified herein or in Section 09901 and shall be dry and clean before painting. Special care shall be given to thoroughly clean interior concrete and concrete block surfaces of all marks before application of finish.
- B. All metal welds, blisters, etc., shall be ground and sanded smooth in accordance with SSPC-SP-10. All pits and dents shall be filled and all imperfections shall be corrected so as to provide a smooth surface for painting. All rust, loose scale, oil, grease, and dirt shall be removed by use of approved solvents, wire brushing, or sanding.
- C. Concrete surfaces shall have been finished as specified in Series 400. Report unsatisfactory surfaces to the Engineer. Concrete shall be free of dust, oil, curing compounds, and other foreign matter, conforming to ASTM D4258.
- D. All submerged concrete shall be brush off blast cleaned. Open all bag holes and air entrained holes with minimum aggregate exposure. Provide a uniform surface profile similar to #100 grit sandpaper.
- E. Concrete block surface shall be smooth and cleaned of all dust, efflorescence, chalk, loose mortar, dirt, grease, oil, tar, and other foreign matter, conforming to ASTM D4258.

- F. All plastic pipe surfaces shall be lightly sanded before painting.
- G. Wood surfaces shall be dry. Sand to obtain a smooth surface. All encrustations shall be removed.
- H. Exposed Pipe: Bituminous coated pipe shall not be used in exposed locations. Pipe which shall be exposed after project completion shall be primed in accordance with the requirements herein. Any bituminous coated pipe which is inadvertently installed in exposed locations shall be sandblasted clean before priming and painting. After installation all exterior, exposed flanged joints shall have the gap between adjoining flanges sealed with a single component polysulfide sealant to prevent rust stains.
- I. Primed or Previously Painted Surfaces and Nonferrous Surfaces: All coated surfaces shall be cleaned prior to application of successive coats. All nonferrous metals not to be coated shall be cleaned. This cleaning shall be done in accordance with SSPC-SP-1, Solvent Cleaning.
- J. Shop-Finished Surfaces: All shop-coated surfaces shall be protected from damage and corrosion before and after installation by treating damaged areas immediately upon detection. Abraded or corroded spots on shop-coated surfaces shall be "Hand Cleaned" and then touched up with the same materials as the shop coat. All shop coated surfaces which are faded, discolored, or which require more than minor touch-up in the opinion of the Engineer shall receive new surface preparation before being repainted. Cut edges of galvanized sheets and exposed threads and cut ends of galvanized piping, electrical conduit, and metal pipe sleeves, that are not to be finished painted, shall be "Solvent Cleaned" and primed with zinc dust-zinc oxide metal primer.
- K. Galvanized and Zinc-Copper Alloy Surfaces: These surfaces to be painted shall be "Solvent Cleaned" and treated as hereinafter specified. Such surfaces not to be painted shall be "Solvent Cleaned."
- L. Aluminum embedded or in contact with concrete must be painted according to the schedule for aluminum in contact with dissimilar materials.

3.02 WORKMANSHIP

- A. General:
 - 1. Primer (spot) and paint used for a particular surface shall, in general, be as scheduled for that type of new surface. Confirm with the paint manufacturer that the paint proposed for a particular repaint condition will be compatible with the existing painted surface. Sample repainted areas on the actual site will be required to insure this compatibility. Finished repainted areas shall be covered by the same guarantee specified for remainder of work.
 - 2. At the request of the Engineer, samples of the finished work prepared in strict accordance with these Specifications shall be furnished and all painting shall be equal in quality to the approved samples. Finished areas shall be adequate for the purpose of determining the quality of workmanship. Experimentation with color tints shall be furnished to the satisfaction of the Engineer and Owner where standard chart colors are not satisfactory.

3. Protection of furniture and other movable objects, equipment, fittings and accessories shall be provided throughout the painting operations. Canopies of lighting fixtures shall be loosened and removed from contact with surface, covered and protected and reset upon completion. Remove all electric plates, surface hardware, etc., before painting, protect and replace when completed. Mask all machinery name plates and all machined parts not receiving a paint finish. Dripped or spattered paint shall be promptly removed. Lay drop cloths in all areas where painting is being done to adequately protect flooring and other work from all damage during the operation and until the finished job is accepted.
4. On metal surfaces apply each coat of paint at the rate specified by the manufacturer to achieve the minimum dry mil thickness required. If material has thickened or must be diluted for application by spray gun, the coating shall be built up to the same film thickness achieved with undiluted material. One gallon of paint as originally furnished by the manufacturer shall not cover a greater area when applied by spray gun than when applied unthinned by brush. Deficiencies in film thickness shall be corrected by the application of an additional coat(s). On masonry, application rates will vary according to surface texture, however, in no case shall the manufacturer's stated coverage rate be exceeded. On porous surfaces, it shall be the painter's responsibility to achieve a protective and decorative finish either by decreasing the coverage rate or by applying additional coats of paint.
5. Paints shall be mixed in proper containers of adequate capacity. All paints shall be thoroughly stirred before use and shall be kept stirred while using. No unauthorized thinners or other materials shall be added to any paint.
6. Only skilled painters shall be used on the work and specialists shall be employed where required.

B. Field Priming:

1. Steel members, metal castings, mechanical and electrical equipment, and other metals that are shop primed before delivery at the site will not require a prime coat on the job. All piping and other bare metals to be painted shall receive one coat of primer before exposure to the weather, and this prime coat shall be the first coat as specified in the painting schedule.
2. Equipment which is customarily shipped with a baked-on enamel finish or with a standard factory finish shall not normally be field painted unless the prefinished equipment is specifically color selected and unless the finish has not been damaged in transit or during installation. Surfaces that have been shop painted and have been damaged, or where the shop coats or coats of paint have deteriorated, shall be properly cleaned and retouched before any successive painting is done on them in the field. All such field painting shall match as nearly as possible the original finish.

C. Field Painting:

1. All painting at the site shall be designated as Field Painting.
2. All paint shall be at room temperature before applying, and no painting shall be done when the temperature is below 50°F, in dust-laden air, when rain or snow is falling, or until all traces of moisture have completely disappeared from the surface to be painted.

3. Successive coats of paint shall be tinted so as to make each coat easily distinguishable from each other with the final undercoat tinted to the approximate shade of the finished coat.
4. Finish surfaces shall not show brush marks or other irregularities. Undercoats shall be thoroughly and uniformly sanded with No. 00 sandpaper or equal to remove defects and provide a smooth even surface. Top and bottom edges of doors shall be painted and all exterior trim shall be back-primed before installation.
5. Painting shall be continuous and shall be accomplished in an orderly manner so as to facilitate inspection. All exterior concrete and masonry paint shall be performed at one continuous manner structure by structure. Materials subject to weathering shall be prime coated as quickly as possible. Surfaces of exposed members that will be inaccessible after erection shall be cleaned and painted before erection.
6. All materials shall be brush painted unless spray painting is specifically approved by the Engineer. The Contractor shall be responsible for all damage caused by overspray or drifting.
7. All surfaces to be painted as well as the atmosphere in which painting is to be done shall be kept warm and dry by heating and ventilation, if necessary, until each coat of paint has hardened. Any defective paint shall be scraped off and repainted in accordance with the Engineer's directions and project specifications.
8. Before final acceptance of the work, all damaged surfaces of paint shall be cleaned and repainted as directed by the Engineer.
9. Any pipe scheduled to be painted and having received a coating of a tar or asphalt-compound shall be painted with two coats of Kop-Coat's Inertol Tar Stop, ICI Paints' Tarsol Standard 7000 or equal before successive coats are applied per the schedule. Tnemec recommends using 69 Hi-Build Epoxoline II over tar, but a test patch must be run initially to test the paint's compatibility with the tar.

3.03 CLEANUP

- A. The premises shall at all times be kept free from accumulation of waste material and rubbish caused by employees or work. At the completion of the painting remove all tools, scaffolding, surplus materials, and all rubbish from and about the buildings, and leave work "broom clean" unless more exactly specified.
- B. Upon completion, remove all paint where it has been spilled, splashed, or splattered on all surfaces, including floors, fixtures, equipment, furniture, etc., leaving the work ready for inspection.

3.04 PAINT

- A. General Notes and Guidelines:
 1. Pipe lines, equipment, or other items which are not listed here shall be assigned a color by the Engineer and shall be treated as an integral part of the Contract.

2. When color coding is specified or directed by the Engineer, it shall consist of color code painting and identification of all exposed conduits, through lines and pipelines for the transport of gases, liquids, or semi-liquids including all accessories such as valves, insulated pipe coverings, fittings, junction boxes, bus bars, connectors, and any operating accessories which are integral to a whole functional mechanical pipe and electrical conduit systems.
3. All moving parts, drive assemblies, and covers for moving parts which are potential hazards shall be Safety Orange.
4. All safety equipment shall be painted in accordance with OSHA standards.
5. All inline equipment and appurtenances not assigned another color shall be painted the same base color as the piping. The pipe system shall be painted with the pipe color up to but not including the flanges attached to pumps and mechanical equipment assigned another color. Tanks shall be painted the color of the piping system that they serve, unless the tank is fiberglass and levels are monitored through the tank.
6. All conduit shall be painted to match its background surface.
7. Building surface colors (as applicable) shall be painted as scheduled in the Finish Schedule or as selected by the Engineer.
8. Control panels shall be factory finished.

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SECTION 11258
ODOR CONTROL BIOSCRUBBER SYSTEM

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. Furnish all labor, materials, equipment and incidentals required for the installation, start-up, warranty, and testing of two complete, bioscrubber systems as shown on the Drawings and specified herein. Each system shall include: two fiberglass reinforced plastic (FRP) bioscrubber vessels, (each equipped with vessel roof access, guardrails, ladders, and personal fall prevention system as shown on the Drawings and specified herein), exhaust stacks, media, wiring and electrical components, a local control panel, automatic irrigation systems, supplemental nutrient supply equipment, and one 55 FRP gallon nutrient tank. If the manufacturer utilizes recirculation systems, the manufacturer shall provide all components for the recirculation systems, including the recirculation pumps, as necessary for fully functional systems. Additionally, for each system, the manufacturer shall be responsible for the fan, ductwork between the fan and bioscrubber vessels (which includes isolation dampers, flexible flange connectors, and other fittings), and the pipe supports for the non-potable water/recirculation pipeline(s) and for a 3/4-inch PVC pipeline, with a minimum 1/4-in PE exhaust sample tubing line inside it, along the bioscrubber vessels. The location of the 3/4-inch PVC pipeline shall be coordinated with the Engineer. This Section gives a general description of system requirements, but does not cover all details, which will vary in accordance with the manufacturer and requirements of the application. It does, however, cover the furnishing, delivery, installation supervision, start-up, warranty, and field testing of all materials, equipment and appurtenances for the complete bioscrubber systems as specified, whether specifically mentioned in this Section or not.
- B. The bioscrubber system manufacturer shall have complete system responsibility for the bioscrubber systems. The manufacturer shall furnish and be responsible for proper functioning of all internal piping and appurtenances. The Contractor shall provide and install water, drain and interconnect piping, water and drain piping insulation, ductwork and power and control wiring to the bioscrubber system. The system manufacturer shall supply the Engineer and Contractor with all necessary wiring diagrams and shall furnish and be responsible for all integral electrical components (transformers, control panels and circuits, interlocks, instrumentation, etc.) required for proper functioning of the systems.
- C. The term "manufacturer" as used in this specification will refer to the manufacturer of the bioscrubber system or the manufacturer's authorized representative.

1.02 RELATED WORK

- A. Section 01170 – Special Provisions.
- B. Motors are specified in Section 01171.
- C. Metal Fabrications are specified in Section 05500.
- D. Control Panels are specified in Section 13390.
- E. Testing, Adjusting, and Balancing is specified in Section 15950.

- F. Fiberglass Ductwork and Accessories are specified in Section 15891.
- G. Instrumentation and controls are included in Division 13 and Division 17.
- H. Piping, duct valves, pipe hangers, and appurtenances are included in Division 15.
- I. Electrical is included in Division 16.

1.03 SUBMITTALS

- A. Submit to the Engineer, in accordance with this Section 01300, all materials and equipment required to establish compliance with this Section. Partial submittals will not be accepted. Submittals shall include the following at a minimum:
 - 1. Descriptive literature, bulletins, and/or catalogs of the equipment.
 - 2. Complete, detailed instructions on the installation of the bioscrubber systems.
 - 3. A statement from the manufacturer that the fabrication is in accordance with this Section.
 - 4. Design structural calculations for vessel construction of each system and for the hold down lug, stamped and sealed by a professional structural engineer registered in Texas.
 - a. Provide detailed drawing showing anchor requirements and locations where anchor bolts must be in place when the support pad is poured.
 - b. Provide signed and sealed (State of Texas PE) calculations that the bioscrubber systems, including vessels, roof access areas, ladders, and safety rails can withstand the wind load and live load design criteria specified in Paragraph 1.07, as well as meet all applicable OSHA requirements.
 - c. Current design does not include wiring restraints. If wiring restraints are required based on the calculations, modifications to the bioscrubber system design, including pad size to allow appropriate access space, shall be performed at no additional cost to the Owner.
 - 5. Certified shop and erection drawings showing all important details of construction and dimensions.
 - a. Dimensions shall include anchor bolt layout and locations, and diameters of air duct, water supply and drainage piping at the limit of work.
 - 6. Drawings and descriptive information on the roof access areas, platforms, personal fall prevention system (including safety rails), and ladders, including the material of construction.
 - 7. Wiring diagram and electrical requirements, including logic diagrams and wiring schematics.
 - 8. Materials of construction, including resin and material used, as well as a statement from the manufacturer that the materials and resin used are suitable for this installation.
 - 9. Submit fan data sheets for each system with a description of the proposed fan, fan size, type, arrangement, materials of construction, weight, motor horsepower, motor type, power supply, frame size, sheave sizes, belts size, number and length. Each submittal shall

include pertinent equipment dimensional data, and a performance curve showing the fan operating point and range. Minimum curve size shall be 8-in by 6-in. Faxed copies of curves are not acceptable. A list of accessories to be furnished shall be included. Copies of operating and maintenance manuals shall be submitted. Refer to Section 01171 for motor requirements.

10. Descriptive information of media including but not limited to pressure drop through media, liquid hold-up data, and media physical characteristics.
 - a. Complete data on the head loss for the air flow through the media at design air flow rate.
 - b. Details of filter media supports.
11. Drawings and descriptive information of nozzles and liquid distribution system to include spray pattern, pressure drop, liquid flow rate, support system details and materials of construction.
12. Acclimation procedure and any required temporary piping during the acclimation period.
13. The total weight of the equipment of each system including the weight distribution at the points of supports.
14. A complete bill of materials for all equipment.
15. A list of the manufacturer's recommended spare parts.
16. A list of special tools.
17. Testing procedures and test equipment.
18. Complete description of surface preparation and shop painting of painted surfaces.
19. Complete Control Panel layout, including size, wiring, schematics internal and external equipment and device arrangement, nameplates and parts catalog cuts as specified in Section 13390.
20. If permanent recirculation systems are provided, submittals for the recirculation pumps shall include as a minimum the following:
 - a. A certified statement from the bioscrubber manufacturer that the recirculation pump is suitable for the bioscrubber system and pumping low pH streams.
 - b. Manufacturer's certified rating data.
 - c. Certified shop drawings showing all important details of construction, dimensions and anchor bolt locations.
 - d. Descriptive literature, bulletins and/or catalogs of the equipment.
 - e. A list of the manufacturer's recommended spare parts. Include gaskets, packing, etc., on the list.
 - f. Data regarding pump and motor characteristics and performance:
 - 1) Prior to fabrication and testing, provide guaranteed performance curves based on shop tests of mechanically duplicate pumping units, showing they meet specified requirements for head, capacity, horsepower and efficiency.
 - 2) For units of same size and type, provide curves for a single unit only.

- 3) Submit curves for guaranteed performance and certified tests as specified on 8-1/2 in by 11-in sheets, one curve per sheet.
- 4) Provide motor information as specified in Section 01171.

B. Submit shop inspection and test certificates.

1. The Engineer retains the right to have a 1-inch diameter core sample extracted from each vessel after delivery for analysis of the resin. The location of the test sample(s) shall be submitted by the manufacturer for the Engineer's review and approval. The hole(s) shall be repaired by the manufacturer, and the analysis shall be paid for by the manufacturer. The Engineer may reject any bioscrubber vessel if it does not meet the standard of the representative samples. Costs for extraction, repair and laboratory analysis shall be by the Contractor.
2. Certificates from the manufacturer shall be submitted stating that the installation of the equipment is satisfactory, the systems have been satisfactorily tested, is ready for operation and the operating personnel have been suitably instructed in the operation and care of the systems.

C. Operation and Maintenance Data.

1. Operations and maintenance instructions shall be furnished to the Engineer as specified herein and in accordance with Section 01730. These instructions shall consist of clean, legible, reproducible manufacturers' manuals prepared by the manufacturer exclusively for the equipment furnished for this installation. Operations and maintenance instructions shall be written in a clear, concise and easily understandable manner to serve in training personnel at this facility. The instruction manual shall include schematic and detailed drawings and diagrams as necessary to accompany the written instructions. A complete set of equipment shop drawings. All component parts shall be clearly identified by name and part numbers cross-referenced. A complete listing of nameplate data for each piece of equipment shall be attached to these instructions. In addition, the instructions shall include troubleshooting data and full preventive maintenance schedules.

1.04 SERVICES OF A MANUFACTURER'S REPRESENTATIVE

- A. A factory representative who has a complete knowledge of the proper operation and maintenance shall be provided as specified herein. Qualifications of the representative shall be submitted for approval. Workday requirements listed are exclusive of travel time and do not relieve the Contractor of obligation to provide sufficient service to place equipment in satisfactory operation. The factory representative shall provide a minimum of two (2) training sessions (typically early morning and late evening) to accommodate plant staff. Owner and Engineer shall be notified in writing a minimum of fourteen (14) calendar days prior to the scheduled training.

| Services Provided by Factory Representative | Minimum ^(a) No. of Trips | Minimum Time On Site Per Trip (hours) |
|---|--|---|
| 1. Supervise installation | 1 | 8 |
| 2. Inspect and approve installation ^(b) | 1 | 4 |
| 3. Supervise initial adjustment ^(c) | 1 | 4 |
| 4. Conduct performance testing ^(c) | 1 | 8 |
| 5. Instruct Owner and Engineer in proper start-up and O&M ^{(c) (d)} | 1 | 4 |
| <p>(a) The manufacturer's factory representative shall be present at frequent enough intervals to ensure proper installation, testing, and initial operation of the equipment.</p> <p>(b) The manufacturer's factory representative shall provide to the Engineer a written certification that the system has been installed in accordance with the manufacturer's recommendations.</p> <p>(c) May be done on the same trip upon completion of prior item if acceptable to the Engineer.</p> <p>(d) Instruction may be given upon completion of Item 4, provided that the test is successful and the O&M manuals have been submitted to and accepted by the Engineer.</p> | | |

1.05 REFERENCE STANDARDS

A. American Society for Testing and Materials (ASTM).

1. ASTM D638 – Standard Test Method for Tensile Properties of Plastics.
2. ASTM D790 - Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
3. ASTM D883 - Definition of terms relating to plastics.
4. ASTM D1505 – Standard Test Method for Density of Plastics by the Density Gradient Technique.
5. ASTM D1525 - Standard Test Method for Vicat Softening Temperature of Plastics.
6. ASTM D1693 – Standard Test Method for Environmental Stress – Cracking of Ethylene Plastics.
7. ASTM D1998 – Standard Specification for Polyethylene Upright Storage Tanks.
8. ASTM D2563 - Recommended Practice for Classifying Visual Defects in Glass Reinforced Plastic Laminate Parts.
9. ASTM D2583 - Test for Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor.
10. ASTM D3299 - “Standard Specification for Filament-Wound Glass-Fiber-Reinforced Thermoset Resin Corrosion Resistant Tanks.

11. ASTM D3982 – Standard Specification for Contact Molded “Fiberglass” (Glass Fiber Reinforced Thermosetting Resin) Ducts.
 12. ASTM D4097-82 - Standard Specifications for Contact Molded Glass Fiber Reinforced Thermoset Resin Corrosion Resistant Tanks.
- B. European Standards (EN).
1. EN 13725 – Air Quality: Determination of Odour Concentration by Dynamic Olfactometry.
- C. American National Standard Institute (ANSI).
- D. Instrument Society of America (ISA).
- E. Anti-Friction Bearing Manufacturers Association (AFBMA).
- F. SPI Proposed Product Standard - Corrosion Resistant Structures - Reinforced Plastics/Composites Division Section, September 1970.
- G. National Electrical Manufacturers Association (NEMA).
- H. Underwriters Laboratories (UL).
- I. National Fire Protection Association (NFPA).
- J. National Electrical Code (NEC).
- K. International Building Code (IBC).
- L. Occupational Safety and Health Administration (OSHA).
- M. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.
- 1.06 QUALITY ASSURANCE
- A. To assure compatibility of all system components and complete system responsibility, ensure that the bioscrubber systems and all accessories and controls specified herein are furnished by a single manufacturer. The manufacturer shall be fully experienced, reputable and qualified in the manufacture of the equipment to be furnished. The equipment shall be manufactured and installed in accordance with the best practices and methods, and shall operate satisfactorily. The bioscrubber systems shall be EcoFilter Reactor by BioAir Solutions, LLC; Biotrickling Filter by Biorem Technologies Inc.; Biotrickling Filter by ECS.
 - B. The odor control systems have been designed around the EcoFilter system by BioAir. The selection of an alternate manufacturer’s equipment may require additional equipment and a

revised layout. The Contractor shall coordinate with potential manufacturers prior to bidding and incorporate costs into the bid price.

1.07 SYSTEM DESCRIPTION

- A. Bioscrubber systems shall continuously and automatically treat and effectively remove hydrogen sulfide and eliminate odors from foul air exhausted from the solids thickening facilities. Exhaust rate capacities shall be 13,000 scfm for Odor Control System (OCS) No. 1 and 9,000 for OCS No. 2. Hydrogen sulfide and other odorants shall be removed by microbial action within synthetic media furnished in the bioscrubbers.
- B. For purposes of testing bioscrubber odor control system performance, inlet concentrations of odorous pollutants will be as summarized in Table 1.

Table 1
Inlet Pollutant Concentrations

| Odor Control System | Pollutant | Inlet Concentration (ppmv) |
|---------------------|--|----------------------------|
| 1 | Hydrogen sulfide - average concentration | 40 |
| | Hydrogen sulfide - peak concentration | 220 |
| 2 | Hydrogen sulfide - average concentration | 20 |
| | Hydrogen sulfide - peak concentration | 150 |

- 1. The pollutant removal performance of bioscrubber systems shall be as indicated in Table 2.

Table 2
Required Odor Removal Performance

| Criterion | A Required Performance After Bioscrubber |
|-----------|--|
| 1 | Average hydrogen sulfide removal efficiency shall be equal to or greater than 99.0 % under both average and peak conditions or 0.5 ppmv, whichever is less stringent. |
| 2 | Outlet odor concentration shall not exceed 1,000 dilutions-to-threshold (D/T) under both peak and average hydrogen sulfide loading conditions OR odor concentration removal shall be 90%, whichever is less stringent. Odor concentration shall be measured and analyzed in accordance with EN 13725-2003. |

- C. Performance testing procedures and terms of the performance guarantee are described in Subsection 3.04 of this Specification.
- D. Each bioscrubber system will consist of two vessels with durable inorganic media, two stacks, one fan, one water distribution system, one nutrient addition system (if necessary) and controls.
- E. The bioscrubber system, including vessels, nutrient tanks, roof access areas, ladders, and fall prevention system (including safety rails) shall be able to withstand 90 mph winds and shall be

in accordance with the wind loading requirements and structural design criteria requirements described in the 2012 International Building Code. The bioscrubber vessel shall be able to withstand a minimum of 300 lb. live load for roof access. The roof access area shall include a ladder, personal fall prevention system, guardrails, and either a platform or non-slip surface; all roof access components shall comply with all applicable OSHA requirements.

- F. The manufacturer shall provide two 55 gallon FRP nutrient tanks (one for each system) suitable for outdoor condition outdoor conditions and filled with nutrient.

1.08 WARRANTY

- A. The manufacturer shall warrant that bioscrubber systems be supplied in accordance with these specifications and shall perform as described herein. The manufacturer shall warrant that the systems will be free from defects in materials and workmanship for a period of one (1) year after startup and final acceptance of the equipment at the Owner's facility. At the manufacturer's discretion, the manufacturer shall repair or provide replacement for any defective components under this warranty provided that any such defect was not the result of misuse of the component by the Owner or the Owner's Agent.
- B. The manufacturer shall warrant the suitability of the biological reactor media and vessel for a period of ten (10) years from the date of final start-up and final acceptance, provided that the Systems are operated in accordance with the manufacturer's Operation and Maintenance Manual provided hereunder. In the event of a failure of the media within the ten (10) year warranty period, the manufacturer shall replace the media at no expense to the Owner or Contractor. In the event of the vessel failure the vessel shall be repaired or replaced with mutual agreement between the owner and manufacturer.

1.09 ENVIRONMENTAL CONDITIONS

- A. Ambient Environment. The ambient temperatures are expected to range between 15 degrees F and 110 degrees F with a relative humidity that will vary from 10 to 100%. The site elevation is approximately 430 feet above mean sea level.

1.10 DELIVERY, STORAGE AND HANDLING

- A. Deliver materials in coordination with installation of the pads, wiring, and piping by others. If equipment is delivered before the pad is ready, the manufacturer shall be responsible for both off-loading and placement of the equipment on the pad.
- B. Exercise care during loading, transporting, unloading, and handling to prevent damage of any nature to interior and exterior surfaces of pipe and fittings.
- C. Do not drop pipe and fittings.
- D. Store materials on the project site in enclosures or under protective coverings in accordance with manufacturer's recommendations and as required by the Engineer.
- E. Assure that materials are kept clean, and all electrical components shall be stored inside.
- F. All equipment and materials shall be properly protected and maintained such that no damage will occur from the time of shipment until the completion of the installation.

- G. The Engineer and Contractor shall inspect all equipment upon delivery. Contractor shall notify manufacturer within 24 hours if damage occurred as a result of shipping.
- H. Vessels shall be shipped in either the vertical or horizontal position. Multiple shipments are acceptable. If shipped in the horizontal position, manufacturer is responsible for any damage to the shape of the units and must orient the vessels vertically upon offloading the vessels.
- I. Flange faces shall be protected from damage by covering with suitable plywood or hardboard, securely fastened.
- J. Pipe and tubing, fittings and miscellaneous small parts shall be crated or boxed.
- K. The equipment shall be inspected by contractor before unloading at the installation site.

1.11 SUBSTITUTION

- A. Any substitutions or deviations in equipment or arrangement, from that specified herein, shall be the responsibility of the Contractor. Any deviation must be accompanied by detailed structural, mechanical, and electrical drawings and additional supporting data for review by the Owner or the Owner's Engineer, and must be stamped and certified by a registered Professional Engineer (PE) in Texas.
- B. All costs associated with the review of substitutions or deviations, and costs to the Engineer, Contractor or Owner associated with project drawing changes as a result of approval of such, shall be borne by the Contractor. There shall be no additional costs to the Owner due to substitutions or deviations.

1.12 TOOLS AND SPARE PARTS

- A. At a minimum, manufacturer shall provide an adequate supply of consumables including nutrient and calibration materials necessary to operate and maintain the equipment specified herein for one-year period after Owner's acceptance.
- B. Manufacturer shall provide the following spare parts:
 - 1. One (1) mesh strainer for water panel.
 - 2. One (1) set of fan bearings.
 - 3. One (1) set of V-belts for fans.
 - 4. If a permanent recirculation system is provided, one (1) spare recirculation pump.
 - 5. Refer to Sections 01171 and 13390 for additional requirements.
 - 6. One nutrient pump repair kit per system.

PART 2 PRODUCTS

2.01 GENERAL

- A. General Description.

1. As shown on the Drawings, each bioscrubber system shall consist of two self-contained totally enclosed vessels (four vessels total), constructed of fiberglass-reinforced resin. The vessels shall contain a durable inorganic media that serves as a support structure for a microbial population without being consumed as a source of nutrients or alkalinity. Non-potable water shall be distributed uniformly over the surface of the media to supply moisture and nutrients to the microbial population and remove process waste. The manufacturer may recirculate water and/or supply a nutrient to the irrigation water dosing system, these systems shall be completely integrated into the irrigation and electrical system. Portable totes or drums shall not be allowed.
2. Each bioscrubber system shall include a fan and control panel to control flow of water and nutrients. As shown on the Drawings and as specified herein, the bioscrubber vessel unit shall include a stack, gauges to monitor pressure drop, manway, roof access area, guardrails, ladder with fall prevention system (including safety rail), manway, sampling port for drainage water, and freeze protection provisions. Freeze protection provisions shall include, yet not limited to, the installation of heater(s) and insulation for the water panels.
3. All equipment shall be new and unused and suitable for the conditions of service to which they will be subjected. Workmanship shall be of the highest quality and shall be carried out by competent and experience workmen.

2.02 DESIGN REQUIREMENTS

- A. All components of the System shall be compatible with the conditions and constituents to which they will be subjected to during normal operation. Compounds with which the materials of construction must be compatible with include, but are not limited to:
 1. Hydrogen Sulfide.
 2. Sulfuric Acid.
 3. Ammonia.
 4. Dimethyl Sulfide.
 5. Methyl Mercaptan and other Mercaptans.
 6. Other Reduced Sulfur Compounds (RSC's).

B. The Systems shall be furnished to meet the following criteria:

| Parameter | OCS No. 1 Value | OCS No. 2 Value | Systems |
|---|-----------------|-----------------|-------------------|
| Capacity | 13,000 | 9,000 | scfm |
| Number of trains | 1 | 1 | train |
| Capacity per train | 13,000 | 9,000 | scfm |
| Number of vessels in parallel per train | 2 | 2 | vessels |
| H2S loading (average/peak) | 40/220 | 20/150 | ppmv |
| Bioscrubber diameter (max) | 12 | 12 | ft. |
| Bioscrubber overall height, including stack (max) | 30 | 24 | ft. |
| Maximum allowable pressure drop for the bioscrubber system. Includes bioscrubber media, fan (suction and discharge sides), isolation damper, and associated ductwork connections. Ductwork headloss upstream of the fan inlet is not included. Refer to Paragraph 2.02 for fan sizing, which describes ductwork headloss upstream of the fan inlet. | 5 | 5 | inch water column |
| Pressure drop across bioscrubber media (max) | 2 | 2 | inch water column |
| System water flow rate (instantaneous) (max) | 50 | 50 | gallons/minute |
| System water pressure (max) | 65 | 65 | psi |
| System water consumption (approx., max) | 20,000 | 20,000 | gallons/day |
| System Nutrient Consumption (approx.) (average) | 0* | 0* | gallons/month |
| Empty bed residence time (EBRT) (min) | 15 | 15 | seconds |

** Note: When the Total N is 3 – 20 mg/L and Total P is 1 – 5 mg/L, the system will not require any supplemental nutrients.*

C. Fiberglass Reinforced Plastic Vessel.

1. All parts of the vessels shall be proportioned to have liberal strength and stiffness and to be especially adapted for the work to be done. Ample room and facilities shall be provided for access.
2. Each bioscrubber vessel shall be a free-standing tower including media and media bed irrigation system. Each reactor vessel shall be constructed of corrosion resistant FRP. The vessel shall be designed to support the required number of media layers and treatment stages. All materials of construction shall be corrosion resistant. The interior of the vessel shall be treated with vinyl ester corrosion barrier for maximum corrosion resistance. The exterior of the vessel shall incorporate a surface veil for superior durability.

3. Equipment built to these specifications shall meet the requirements of ASTM D3299 for filament wound tanks, ASTM D4097 for contact molded tanks and ASTM 3982 for contact molded duct.
4. Vessels built to these specifications shall have the following information printed on nameplates of appropriate size for the equipment involved.
 - a. Name of Manufacturer
 - b. Capacity in Cubic Feet.
 - c. Chemical Environment.
 - d. Manufacturer Serial Number.
 - e. Year Built.
 - f. Name and Equipment Number.
 - g. Purchase Order Number.
 - h. Design Pressure and Temperature.
 - i. Resin.
5. Resins.
 - a. The resin used shall be resistant to corrosion by wet hydrogen sulfide and other corrosive gases present in wastewater treatment plants. A single, fire retardant resin shall be used throughout. Flame spread ratio shall not exceed 25 when tested in a Steiner Test Tunnel in accordance with ASTM E84.
 - b. Antimony or NYACOL additives shall not be used to achieve flame spread index.
 - c. Acceptable products:
 - 1) Derakane 510-B-400.
 - 2) Cor VE 8401.
 - 3) AOC Vipel K022.
 - 4) Reichold's Dion Impact 9303-54.
 - 5) Or Engineer approved equal.
 - d. Each bioscrubber vessel shall be constructed of factory fabricated fiberglass reinforced fire retardant vinyl ester resin as follows:
 - 1) The shell shall consist of an interior layer, a corrosion barrier, a structural layer and an exterior layer.
 - 2) No thixotropic agents may be used in the corrosion barrier.
 - 3) Reinforcing material shall be commercial grade glass fiber containing a coupling agent to produce a suitable bond with the resin used.
 - 4) Interior layer shall be a minimum of 20 mils thick single layer Nexus or C glass surface veiling in a resin rich surface. Resin content shall be approximately 90 percent.
 - 5) Corrosion barrier shall be a minimum of 100 mils thick of Type E glass strand mat, applied in two layers of equal thickeners. Resin content shall be approximately 70 percent.
 - 6) Structural layer shall be alternating layers of Type E glass, reinforced by interweaving of chopped strand mat and woven roving continuous helically filament winding glass. Resin content shall be approximately 60 percent.
 - 7) Exterior layer shall be a parafinized gel coat with UV inhibitors.
 - e. All surfaces shall be finished so as to obtain complete cure of the resin without air inhibition. The finished laminate shall be as free as commercially practicable from visual defects such as foreign inclusions, dry spots, air bubbles, pinholes and pimples. Each vessel shall be post cured per the resin manufacturer's recommendations and shall conform to the resin manufacturer's minimum standard for Barcol hardness.

- f. The inner surface shall and interior layer shall meet the visual acceptance criteria in Table 5 ASTM C 582 process side. Exterior shall meet the referenced criteria for the non-process side.
- g. The structural layer or body of the laminate shall be of chemically resistant construction suitable for the service, providing the additional strength necessary to meet the tensile and flexural requirements. Where separate layers such as matt, cloth, or woven roving are used, all layers shall be lapped a minimum of 1 in. Laps shall be staggered as much as possible. If woven roving or cloth is used, the layer of chopped strand glass shall be placed as alternate layers. All filament wound structural layers shall be per ASTM D 2996. The exterior surface shall be relatively smooth with no exposed fibers or sharp projections. Handwork is acceptable, but enough resin shall be present to prevent fiber show.
- h. Any grinding, repair, or sanding of interior surfaces shall be covered with a laminate duplicating the inner corrosion liner and parafinized top coat. All exposed edges shall be sealed with the same resin as used on each vessels and shall be fully post cured.
- i. There shall be no longitudinal joints in the axial direction of the cylindrical shell. The entire shell thickness shall be built up prior to removal of the shell from the mandrel.
- j. The minimum wall thickness shall be per structural calculations but no less than 3/8 in for all vessels. Each vessel shall have external circumferential reinforcing ribs and bottom knuckle reinforcement as dictated by the design and the referenced ASTM standards. The flat bottom of both rectangular and cylindrical vessels shall be constructed integral to the straight sides off of a singular mold with no seams. Laminating flat bottom to vertical sides will not be accepted. Knuckle shall be seamless having a minimum radius of 1 1/2-inch.

D. Equipment & Tank Connections.

- 1. Lifting lugs (minimum of three) shall be provided for use in transporting and placing the vessel.
- 2. Hold downs (minimum of four) each consisting of a fiberglass reinforced polyester gusseted hold down lug laminated to the vessel sidewall and a Type 316L stainless steel anchor clip. The anchor clip shall be used for anchor bolting to the concrete foundation and clamping to the hold down lug. The hold down systems shall be of sufficient strength to hold the vessel and any exhaust duct the vessel supports against all loads.
- 3. Vessel manufacturer shall provide anchor requirements and locations to the Contractor where anchor bolts must be in place when the support pad is poured.
- 4. Anchor bolts shall be provided by the Contractor.
- 5. Vessel connection flanges shall be compatible with connecting piping and duct work and shall conform to the following:
 - a. Vessel nozzles shall be 150 psi rated flanged nozzles. Press molded or compression molded flanged nozzles will not be accepted.
 - b. All nozzles 6 in diameter and smaller shall be of the blade gusseted configuration meeting strength requirements of 1500 ft. lbs. of bending and 2000 ft. lbs. torque.
 - c. Nozzles overlays shall be as specified in ASTM D 3299 or ASTM D 4097.
 - d. The area on the back of all flanges around each bolt hole shall be the diameter of a standard washer and shall be flat and parallel to the flange face. This area shall be spot faced, if necessary, to meet this requirement. Flanges shall be manufactured by

the hand layup method and shall conform to ANSI 150 lb. standard dimensions for bolting.

- e. Blind flanges and access doors shall be the same thickness and material as the flanges to which they are attached. Tolerance as flatness shall be the same as for flanges.
 - f. Manways on bioscrubber vessel and equipment shall be a minimum of 24" I.D.
 - g. All access doors and bolted attachments shall be provided with 1/8-in thick EPDM gaskets and 316 stainless steel nuts, bolts and washers.
 - h. Access doors shall be constructed of industrial grade, clear polycarbonate that will not undergo structural deterioration or clouding and shall be of a minimum thickness of 1/2-inch.
 - i. Supports shall be suitably attached to the outer vessel walls as necessary to support vessel piping and interconnecting FRP ductwork and shall meet loading criteria specified in Paragraph 1.07.
6. Threaded couplings shall not be allowed below the liquid level.

E. Ladders and Personal Fall Prevention System.

1. Provide a ladder and personal fall prevention system for each bioscrubber tank as shown on the Drawings and specified herein. The complete system shall meet all applicable OSHA requirements. The personal fall prevention system shall be designed, engineered, and manufactured, and shall include the following:
 - a. A rigid notched carrier rail.
 - b. A means of attaching the carriers easily to ladder.
 - c. A means of dismounting at the top of ladders.
 - d. Two-locking mechanisms which travel on the carrier.
 - e. Two-full body harnesses with double (split) shock absorbing lanyards to connect the workman to locking mechanism.
2. The complete personal system shall allow the worker to operate freely in a normal climbing position. The device is to be installed in accordance with the manufacturer's instructions in such a manner to enable the worker to be attached to the device at all times during the climb without having to remove his or her hands from the ladder to operate the system effectively. This shall also enable the worker to be attached safely to the system before rotating onto the ladder.
3. The ladder and carrier rail shall be made of aluminum. All ladder and fall prevention system components shall be durable, be corrosion resistant. Unless otherwise specified in this section ladders shall meet requirements specified in Section 05500.
4. Ladder and personal fall prevention system shall adhere to structural requirements outlined in Paragraph 1.07-E.
5. The locking sleeve and safety-locking mechanism shall consist of the following:
 - a. Sleeve: Cast manganese bronze tensile strength of 110,000 P.S.I.
 - b. Locking Pawl: Tensile strength of 110,000 P.S.I.
 - c. Sleeve Springs: Dual stainless steel springs.
 - d. Roller Bearings: Six steel roller bearings.
 - e. Snaps and Links: The snap shall be drop forged steel with a proof test of 5,000 pounds.

6. The full body harness with integrated belt shall consist of the following:
 - a. Harness shall be designed to perform optimally with all other components of fall prevention system.
 - b. Harness shall meet ANSI A10.14 1991 and CSA Z259.10.
 - c. Harness shall be composed of premium 1-3/4" Nylon webbing.
 - d. Strength of webbing shall be 6,500 lbs.
 - e. All load bearing components shall be rated to 5,000 lbs. and made of drop forged plated steel.
 - f. Sliding back "D" ring on full body harness shall be used for fall arrest.
 - g. Belt shall be manufactured of two layers of one and three quarter (1-3/4) inch webbing with a two (2) inch back support pad.
 - h. Front "D" ring on belt shall be used for climbing with fall prevention system.
 - i. Harness shall have double (split) bungee cord type shock absorbing lanyard. Lanyard shall be four foot-six inches (4'-6") long un-deployed, with two and one quarter inch (2'-1/4") throat large rebar locking snap hooks on each lanyard.
7. The personal fall prevention system shall be by: Miller, North Safety Products, or approved equal.
8. The bioscrubber manufacturer shall coordinate with the fall prevention system manufacturer and the Contractor for recommended installation of the ladder and fall prevention system.
9. A lockable, mountable, weatherproof storage box shall be provided to store safety harness and accessories. A caution sign shall be provided at the lowest point of access to the ladder. The sign shall read "CAUTION – Safety Equipment Required When Climbing Ladder". The sign shall be secured to the wall.
10. Contractor shall provide fall prevention training to plant staff personnel as part of the fall prevention system and devices for this project. This training shall be provided by a firm certified in fall prevention training. Contractor shall submit information on the training firm and training agenda for approval by the Owner prior to scheduling the training. The information shall be submitted after the pre-construction conference, and before substantial completion of the project. Training shall be as scheduled by the Owner. This training shall be subsidiary to other bid items in this section.

F. Fiberglass Reinforced Plastic Fan.

1. The fans shall be sized as follows:
 - a. OCS No. 1: 13,000 scfm, adjusted to 11,000 scfm for current phase.
 - b. OCS No. 2: 9,000 scfm.
2. The fans shall be single-width single-inlet as designed and manufactured by The New York Fan Company, Hartzell Fan Co., Verantis, or approved equal.
3. The fans shall be constructed such that all surfaces in contact with the corrosive gas stream are to be made of corrosion-resistant FRP.
4. All nuts, bolts and fasteners in contact with the gas stream shall type 316 stainless steel.

5. Fans shall be AMCA Arrangement 1, 8, 9, 9F or 10. AMCA Arrangement 4, which places the motor shaft in the corrosive air stream is unacceptable.
6. Fan ratings shall be based on tests made in accordance with AMCA Standard 210 and licensed to bear the AMCA Certified Ratings Seal for Air Performance. Fans not licensed to bear the AMCA Seal for performance shall be tested, at contractor's expense, in an AMCA Registered Laboratory.
7. Fan brake horsepower's shall be less than or equal to 20 HP for OCS No. 1 and 20 HP for OCS No. 2, each at 10 inches static pressure. This static pressure accounts for the pressure drop in the bioscrubber system including the scrubber, media, damper, fan plus an additional 5 inches for exhaust system ductwork and for specified flow rates at site elevation of approximately 430 feet above sea level. If the manufacturer's system has less headloss through their system, they may reduce the horsepower requirements as necessary for their system.
8. Fan motors shall be selected to be non-overloading for the entire fan curve range and for the temperature and humidity range in Paragraph 1.09-A.
9. Fans shall be assembled with OSHA compliant shaft and motor guards.
10. Fan inlet and outlet connections shall be flanged type.
11. Fans shall be constructed in accordance with ASTM D-4167 standard specification for fiber-reinforced plastic fans and blowers to ensure structural integrity.
12. All parts exposed to the gas stream shall be constructed of, or encapsulated in, an FRP laminate capable of resisting continuous airstream temperatures of up to 250 degree F. All resins shall be clear to allow detection of subsurface imperfections. Use of pigments, gel coats, inhibitors and additives which may disguise flaws in the laminate are prohibited.
13. Fan housing shall be constructed of a fire-retardant polyester or vinyl ester resin with an ASTM E84 Class I rating. Housing laminate construction shall conform to ASTM Standard C-582.
14. Wheel shall be of backwardly-inclined, non-overloading design for increased efficiency. Wheel shall be fabricated of a fire-retardant vinyl ester resin with an ASTM E84 Class I Rating.
15. Wheel hub shall be permanently bonded to the shaft and completely encapsulated in FRP to ensure corrosion-resistant integrity. Steel wheels coated with FRP, or wheels with taper-lock hubs are not acceptable.
16. Shafts shall be 316 stainless steel.
17. The fan motors shall be horizontal, TEFC, severe duty, squirrel caged induction type, 460 Volt, 3 Phase, 60 Hz with Class F insulation and a minimum 1.15 service factor, suitable for full voltage starting and continuous operation at 50 degrees C ambient temperature at the specified loads. Provide motor with heater as specified in Section 01171. The fan motor shall be suitable for operation in a Class 1 Division 2 environment.

18. Bearings shall have heavy-duty grease lubricated ball or roller bearings with a minimum ABMA L-10 life of 40,000 hours minimum for both fan and motor. Bearings shall have ample thrust provision to prevent end play during the normal life of the bearing.

G. Fan Schedule.

1. 13,000 scfm for OCS No. 1 (adjusted to 11,000 scfm for current phase) and 9,000 scfm for OCS No. 2.
2. Ambient temperature range of 15 to 110 deg. F.
3. Suction pressure at connection to bioscrubber system will be minus 5.0 inches w.c.
4. Size, speed, and horsepower shall be determined by the bioscrubber system manufacturer. The horsepower shall not exceed 20 HP.
5. Sound power level shall not exceed 90 DBA at 5 feet.
6. Flanged connections, flexible connections, FRP transition pieces, and FRP dampers: Refer to Section 15891 (Fiberglass Reinforced Plastic Ductwork and Accessories).

H. Control Panels.

1. General.
 - a. Each bioscrubber system shall have the control logic circuits mounted in a single Master Control Panel (MCP) enclosure provided by the manufacturer and located outdoors near the bioscrubber fan, and specified herein. The MCP enclosures shall be NEMA 4X 316 stainless steel, constructed by a UL certified control panel build facility and supported by the appropriate UL labeling.
 - b. The bioscrubber MCPs shall contain all controls, timers, relays, PLC, main circuit breaker, and motor starters for manual and automatic starting, stopping, and sequencing of the bioscrubber systems. The MCPs shall have all controls to provide the control sequences specified herein. The bioscrubber MCPs shall include switches, pushbuttons, and indicator lamps and specified herein. The bioscrubber MCP shall be provided with a single 3-phase 480 volt source of power and shall include all power transformers, if required. Systems requiring more than one electrical connection shall not be allowed.
 - c. Controls shall be tested by the panel builder and by the bioscrubber manufacturer prior to shipment to owner.
 - d. All signal interface wiring between MCPs and the existing SCADA PLC shall be provided by the electrical contractor.
 - e. The bioscrubber control system shall be a Type A packaged control system type as specified in Section 13390.
2. Panel and Enclosure Construction.
 - a. The MCPs shall meet the requirements of Section 13390.
 - b. MCPs shall include a main circuit breaker as specified in Section 13390.
 - c. A six-digit, non-resettable elapsed run-time meter shall be installed on the front of each MCP for each fan and pump drive motor. Elapsed run-time meters shall be ENM, or equal.

- d. The MCPs shall house motor starters for drive motors. Starters shall be as specified in Section 13390.
 - e. Each MCP shall be provided with a surge protection unit on the load side of 120VAC /1Ø/60 Hz control power transformer. Control power transformer shall have both primary and secondary overcurrent protection and shall be sized by the bioscrubber supplier.
 - f. All necessary power conditioning and DC power supplies shall be furnished inside each MCP for proper operation of the equipment.
 - g. The MCPs shall include intrinsically safe barriers for termination of any signals to/from hazardous Class 1, Div. 1 and Class 1, Div. 2 areas. Provide 2-in separation or barriers between the conductors of intrinsically safe circuits and non-intrinsically safe circuits meeting the requirements of NEC 504.30.A.2.
 - h. PLC shall be required. PLC signals associated with the equipment to be controlled shall be wired directly to the PLC.
 - 1) PLC shall be a Type 2 Programmable Logic Controller as specified in 13390 and 17600.
 - 2) PLC discrete outputs shall drive a relay to provide a dry contact to interface with motor starters located in the MCP or in control panels furnished by others. Relay contacts shall be rated 10 amp at 120VAC. PLC input cards shall have optical isolation on individual channels.
 - 3) The manufacturer shall supply all necessary ventilation and cooling to accommodate a PLC in the ambient conditions.
 - i. The system supplier shall provide display and interface functionality at the LCP using knobs, buttons, switches, and indicator lamps. Digital touch screens or Operator Interface Units shall not be used as a primary form of control. Digital touch screens shall not be located on the exterior of the control panel.
 - j. Provide sun shield as specified in Section 13390.
 - k. Provide environmental controls as specified in section 13390.
 - l. Provide all other appurtenances required for a complete and fully operational control panel.
3. Each MCP shall include the following functions:
- a. Control of fan motor starter.
 - b. Control of water flow to the units with PLC and manual override, if required.
 - c. Control of nutrient flow.
 - d. If a recirculation pump is provided, control of the recirculation pump starter.
 - e. Dry contacts for plant SCADA system for common alarm, fan run status for the odor control inlet fan. If a recirculation pump is provided, also provide a dry contact for pump run status.
 - f. Provide a totalizing meter to track the consumed irrigation water on the control panel. The totalizing meter shall be a resettable meter that displays the total water consumed.
 - g. Ventilation and/or cooling as required to protect the PLC.
4. Instrumentation Specifications shall include but not be limited to, the following:
- a. Flow rate shall be measured by a turbine flow meter, Signet Rotor-X Paddlewheel or approved equal.
 - b. Flow Switch shall be vane or disc actuated with Form C snap action, hermetically seal switch rated for 10A, 125/250 VAC. Switches for pipe sizes 3/4 to 1-1/2 shall be provided with a flow body. Switches great than 1-1/2 shall be installed directly into field piping. Flow body and all wetted parts shall be 316 stainless steel. Switch

- housing shall be NEMA 4X and manufactured by Magnetrol F50 and F10 or approved equal.
- c. Differential Pressure Transmitters shall provide accuracy of 0.075% of span or better, NEMA 4X (IP66), and shall be Rosemount 3051CD or approved equal.
 - d. Pressure Switches shall be diaphragm actuated and provide repeatability or better than 1% of full scale. Set point shall be field adjustable with fixed dead band and automatic reset. Housing shall be NEMA 4X (IP65) with hermetically sealed switches, single pole double throw (SPDT) and rated for 10A at 230VAC. Switches shall be manufactured by Ashcroft or approved equal.
 - e. Pressure Gauges shall be bourdon tube actuated dial face and provide accuracy of 1% of span or better, Case shall be phenolic shock resistant or type 316 stainless steel. Gauge shall be manufactured by Ashcroft or approved equal.
 - f. Temperature Transmitters shall be three wire platinum RTD and provide accuracy of plus or minus 0.2 deg. C, NEMA 4X (IP66) and shall be Rosemount 3144P or approved equal.
 - g. High Level Float Switch shall be a hermetically seal reed switch rated for 120/240 VAC. Level Switch shall be Series F6 & F7 Horizontal Level Switch or approved equal.
 - h. All instruments shall be listed for use in Class I Division II environments.
5. The display on the control panel shall include the following items, at a minimum:
- a. Odor Control Fan failure
 - b. Odor Control Fan run status
 - c. High water level.
 - d. Irrigation water flow
 - e. Irrigation water and nutrient water totalization
 - f. If a recirculation pump is provided, pump run status and pump failure
 - g. Irrigation water
 - h. Alarms as shown on the Drawings
- I. Synthetic Media.
1. The media shall be either structured media as supplied by BioAir or random media as supplied by Biorem, or ECS. Regardless of whether the media is structured or random, the material shall be synthetic, chemically resistant polyurethane, polyethylene, or polyvinyl chloride.
 2. The media shall resist shrinking or swelling with varying moisture content.
 3. Media layers shall be removable single media blocks or randomly dumped.
 4. The treatment layers shall be designed not to short circuit or be subject to channeling under operating conditions.
 5. The manufacturer is responsible for providing the proper media content to ensure system meets specified performance.
 6. Organic media shall not be allowed.
 7. Non-synthetic inorganic media shall not be allowed.

8. Manufacturer shall warranty the media for a minimum of 10 years. Warranty shall be a full replacement warranty and non-pro-rated.

J. Irrigation System.

1. Each reactor shall be configured with sufficient fluid spray nozzles to provide sufficient irrigation.
2. Each spray nozzle shall be inspected and tested by the manufacturer to ensure even dispersion of irrigation water, and certified to be operating properly prior to shipment.
3. When required, a nutrient addition system shall be provided to allow the Owner to supplement the nutrients in the non-potable irrigation water supply, or to use potable water for irrigation.

K. Water Panel.

1. The water panels shall be constructed of 316 stainless steel and shall be of a modified NEMA 4X design. NEMA 4, 12, and 3R ratings shall not be allowed. Materials of construction other than 316 stainless steel shall not be allowed.
2. The water panels shall contain all necessary piping, valves and instruments for proper operation of the system. Provide and install a schedule 80 inline, wye strainer for the non-potable water line. A single water panel shall be provided for each bioscrubber vessel.
3. Provide panel heater as specified in section 13390.

L. Nutrient Tank.

1. The nutrient tank shall be constructed of the same material as the vessel.
2. The tank shall have a low level switch.
3. The tank shall have a water connection with ball valve.
4. A 12" diameter flanged opening shall be provided on the top of the tank with 316 SS quick-connections, bolts are not allowed.
5. The tank shall have a 2" flanged drain fitting.
6. The tank shall be fastened to the concrete sufficient to withstand the specified wind loads.
7. The tank shall have a means to release vacuum while the tank is draining during operation.

M. Recirculation System.

1. Temporary: If a temporary recirculation system is necessary for start-up, the manufacturer shall provide a fully functional temporary recirculation system.
 - a. The temporary recirculation system shall be utilized as required for the full acclimation and start-up of the bioscrubber and shall remain in the property of the manufacturer at all times.

- b. Contractor shall disconnect the temporary recirculation system once start up is complete and connect the system for normal operating mode per manufacturer's instruction.
 2. Permanent: If a permanent recirculation system is required for the bioscrubber operation, the manufacturer shall provide a fully function permanent system, including a recirculation pump as specified herein.
- N. Recirculation Pump (if necessary based on the manufacturer's recommendation and proposed system).
 1. Each recirculation pump shall pump the low pH liquid from the vessel's sump to the spray headers.
 2. Each pump shall have a capacity adequate to meet necessary irrigation pressure and flow requirements for a fully functioning recirculation system. The pump capacity and head shall be based on the selected manufacturer's system and may be revised as necessary in order to provide a functional system. All deviations shall be submitted to the Engineer for review and approval.
 3. Pump motor horsepower shall be a 7.5 HP (maximum).
 4. The number of recirculation pumps is one (1) per bioscrubber system. One (1) shelf spare pump shall be provided for use at both systems.
 5. Pump shall be seal less, magnetically driven, horizontal, single stage, base mounted, end suction centrifugal configuration manufactured in accordance with ANSI Horizontal End Suction Pumps for Chemical Process.
 6. The pump casings have a top discharge. Suction and discharge connections shall be 150 lb. standard ANSI flanges.
 7. The pump casings shall be constructed of polypropylene and shall be designed to be suitable for pressures of at least 1.5 times the shut off head of the pump.
 8. Magnets shall be rare earth, high performance.
 9. The impellers shall be constructed of the same material as the casing and shall be fully open with contoured passages. The impellers shall be balanced for high efficiency.
 10. The pump shafts shall be of Type 316 stainless steel and shall be manufactured such that deflection is minimal. Where the shaft is directly exposed to the liquid being pumped, the shaft shall be protected by polypropylene shaft sleeves.
 11. The shaft shall be guided by low PV stationary bearings and rotary sleeve/thrust bearings that are resistant to corrosion from the process fluid.
 12. Each pump shall have an electrically non-conductive containment shell that is resistant to corrosion from the low pH process liquid.

13. The bearing frames and bearing housing adapters shall be of cast iron construction with chemically resistant two-part epoxy resin coating and shall have a registered fit with the pump casings.
 14. The recirculation pump shall be able to operate outdoors and be exposed to sunlight and hot temperatures, specified in Paragraph 1.09-A, without pump material degradation.
 15. The recirculation pump motors shall be horizontal, TEFC, severe duty, squirrel caged induction type, 460 Volt, 3 Phase, 60 Hz with Class F insulation and a minimum 1.15 service factor, suitable for full voltage starting and continuous operation at 50 degrees C ambient temperature at the specified loads. The pump motors shall be suitable for operation in a Class 1 Division 2 environment. Provide motor with thermal protection and heater as specified in Section 01171.
 16. If required, fiberglass base plates shall support the pumps and motors. The base plates shall have holes mounting to a concrete equipment pad. The pumps and motors shall be assembled on the base plates in the manufacturer's shop.
 17. Brass or stainless steel nameplates giving the name of the manufacturer, model number, the rated capacity, head, speed and any other pertinent data shall be permanently attached to each pump.
 18. Brass or stainless steel nameplates giving the name of the manufacturer, serial number, model number, horsepower, speed, voltage, amperes and other pertinent data shall be attached permanently to each motor.
 19. The pump manufacturer shall supply all drive units and factory mount them on a common baseplate with the pumps. Acceptable vendors:
 - a. Vanton Pump and Equipment Corp
 - b. ANSI Mag
 - c. Goulds Pumps
 - d. Or Engineer approved equal
- O. Exhaust Stack.
1. Provide a connection location (flange outlet or NPT) and necessary fitting(s) such that the 1/4-in exhaust sample PE tubing inside the 3/4-inch PVC pipeline can be connected to each exhaust stack. The location of the 3/4-inch NTP shall be coordinated with the location of the 3-inch pipe supports along the vessel. The sample connection and piping described above shall also be provided for the inlet side of the system. The manufacturer shall coordinate the inlet sample location with the Engineer.
- P. Test ports
1. Provide test ports as shown on the Drawings, at minimum. Additional test ports shall be provided per the manufacturer's recommendation at no additional cost to the Owner

PART 3 EXECUTION

3.01 INSTALLATION OF BIOSCRUBBER SYSTEM

- A. The manufacturer/supplier shall be responsible for shipping the equipment and shall coordinate with the Contractor for proper off loading at the job site. The Contractor shall provide rigging services to place the equipment on the concrete pad. Anchor bolt holes shall be provided in accordance with the manufacturers shop drawing submittal. Any changes in bolt placement due to errors in the shop drawing shall be the responsibility of the manufacturer. The manufacturer or authorized representative shall have a technical representative, who is experienced in installing the equipment, on-site at the time of installation.
- B. The exhaust duct, power and control wiring, water supply, and drain line will be brought to the concrete pad by others. The Contractor will be responsible for connecting the exhaust duct, power and control wiring.
- C. Installation of the systems shall be completed by Contractor in accordance with the manufacturer's written instructions. At the discretion of the manufacturer, a manufacturer's technical representative may be present during the installation.

3.02 UTILITIES

- A. Electrical:
 - 1. A single 480V / 3-phase / 60 Hz electrical connection shall be made by the Contractor to the control panel. Systems requiring separate 110V and 480V power supplies shall not be allowed.
- B. Water:
 - 1. Water supply lines shall be provided by the Contractor as shown on the Drawings. The water supply shall be provided at a sufficient pressure and flow as required for system irrigation.
- C. Connection of the water supply to the water panel shall be completed by the installing Contractor.
- D. Heat tracing and aluminum jacketed insulation, in accordance with Section 15250, shall be provided by the Contractor.

3.03 START-UP

- A. A representative of the manufacturer who is experienced in the start-up of bioscrubber systems shall provide the services during start-up.
 - 1. Check all fan and water flow functions.
 - 2. Measure air flows after the odorous air collection system is adjusted to the specified flow rates. The Contractor shall coordinate testing and balancing per Section 15950.
 - 3. Make all provisions required to minimize acclimation time of the bioscrubber systems.

4. Install all sampling taps in the bioscrubber required for acceptance testing.
5. An acclimation period of up to 28 days after initial startup shall be allowed. Once the acclimation period is completed, the manufacturer shall commence Performance Testing as outlined in the following section.

B. Start-up of the systems shall be the responsibility of the manufacturer, who shall furnish factory-trained personnel to complete this activity. Start-up will commence following a visual inspection and check out of the systems by the manufacturer's technical representative.

3.04 ACCEPTANCE TESTING

- A. Acceptance testing shall not commence until to the Testing and Balancing Report for the entire ductwork system is submitted and approved by the Engineer.
- B. The Owner shall schedule acceptance testing within 90 days of start-up. The total acclimation period shall not exceed 28 days.
- C. The fan speeds or inlet dampers shall be adjusted so that 5,500 scfm (current phase) goes to each vessel of OCS No. 1 and 4,500 scfm goes to each vessel of OCS No. 2, with the media microbial population fully developed.
- D. Sample collection equipment and hydrogen sulfide monitoring instruments will be provided by the manufacturer but must be approved by the Engineer.
- E. Inlet and outlet hydrogen sulfide concentrations will be monitored and logged continuously over a period of 24 hours. Inlet measurements shall be collected from the main duct upstream of the bioscrubber system inlet. Outlet conditions will be monitored at the discharge stack for each bioscrubber vessel.
- F. For each bioscrubber system, two inlet odor sample and four outlet odor samples (two per vessel) will be taken concurrently under average conditions, as shown on hydrogen sulfide monitors.
- G. Thus, there will be a total of twelve (12) odor samples. The samples shall be sent to St. Croix Sensory, Inc. of Stillwater, MN by overnight delivery for odor analyses. Odor concentrations will be measured and analyzed in accordance with EN 13725.
- H. To pass the acceptance test, the bioscrubber systems shall meet both hydrogen sulfide and odor reduction criteria set forth in Table 2, shown in Paragraph 1.07.
- I. If either system fails the acceptance test, the manufacturer shall conduct up two additional rounds of testing at no expense to the Owner. If the system does not pass after the additional testing, the manufacturer shall make whatever provisions are required to meet the criteria as defined in Paragraph 1.07 at no expense to the Owner. Failure to pass the acceptance test within 3 months of the initial acceptance test may result in forfeiture of the final payment, at the sole discretion of the Owner.

END OF SECTION

SECTION 11318
SUBMERSIBLE CHOPPER PUMPS (SCUM/FOAM PUMPS)

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. Furnish all labor, materials, equipment and incidentals required, and install, complete and ready for operation, four submersible wet pit centrifugal chopper pumps as shown on the Drawings and as specified herein to pump scum from the four gravity thickeners to the sludge holding tank in the Sludge Transfer Building.
- B. Electric motors shall be furnished as part of the work of this section and shall conform to the requirements of Section 01171.

1.02 RELATED WORK

- A. Concrete work and installation of anchor bolts is included in Series 400, but anchor bolts for these units shall be furnished under this Section.
- B. Electric motors shall be furnished as part of the work of this section and shall conform to all applicable portions of Section 01171.
- C. Field painting is included in Section 09902.
- D. Control panels shall be furnished as part of the work of this section and shall conform to all applicable portions of Section 13390.
- E. Instrumentation is included in Division 13 and Division 17.
- F. Mechanical piping, valves, pipe hangers and supports are included Division 15.
- G. Electrical work is included under Division 16.
- H. Pump temperature and leak detection units (as specified in this Section) shall be furnished under this Section for installation in the motor control centers provided under Division 16. Coordinate the installation with the electrical contractor and the MCC supplier.

1.03 SUBMITTALS

- A. Submit, in accordance with Section 01300, copies of all materials required to establish compliance with the specifications. Submittals shall include the following:
 - 1. Certified shop and erection drawings showing all important details of construction, dimensions and anchor bolt locations.
 - 2. Descriptive literature, bulletins and/or catalogs of the equipment.
 - 3. Data on the characteristics and performance of the pumps. Data shall include guaranteed performance curves, based on actual shop tests of duplicate units, which show that they meet the specified requirements for head, capacity, efficiency, allowable NPSH, allowable suction lift and horsepower. Curves shall be submitted on 8-1/2-in by 11-in sheets.

4. The total weight of the equipment including individual weights of the pump and motor.
 5. A complete total bill of materials for all equipment.
 6. All information required by Section 01170.
 7. A statement indicating and documenting the life of all bearings.
 8. Complete data on motors and in accordance with Section 01171.
 9. Complete description of surface preparation, shop prime and finished painting.
 10. Factory performance test data as specified in Paragraph 1.06.
 11. Complete master wiring diagrams, elementary or control schematics, physical dimensional or elevation drawings and system single line drawings specific to this Contract. Standard preprinted sheets or drawings simply marked to indicate applicability to this Contract will not be acceptable.
 12. Submittal information shall include detailed information indicating wiring connection points for all external devices and controls as specified herein.
 13. Complete description of the control panel's required components in accordance with Section 13390.
 14. Detailed point-to-point wiring diagrams that show all terminal blocks and internal wire tag numbers and block wiring diagram that show number, type and size of all conductors connected externally to the control panel(s).
 15. Field test procedures and results as specified in PART 3.
 16. Manufacturer's warranty.
 17. Electrical accessory information, including the moisture and temperature sensors and association relays including schematic wiring diagram and description of all components.
- B. In the event that it is impossible to conform to certain details of the specifications because of different manufacturing techniques, describe completely all nonconforming aspects.
- C. Operation and Maintenance Data.
1. Operating and maintenance instructions shall be furnished to the Engineer as provided for in Section 01730. The instructions shall be prepared specifically for this installation and shall include all cuts, drawings, equipment lists and descriptions that are required to instruct operating and maintenance personnel unfamiliar with such equipment.

1.04 REFERENCE STANDARDS

- A. American National Standards Institute (ANSI)
- B. American Bearing Manufacturers Association (ABMA)

- C. National Electrical Manufacturers Association (NEMA)
- D. American Gear Manufacturers Association (AGMA)
- E. Occupational Safety and Health Administration (OSHA)
- F. National Electric Code (NEC)
- G. National Electrical Manufacturers Association (NEMA)
- H. Underwriters Laboratories (UL)
- I. Where reference is made is one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

A. Manufacturer Qualifications and Requirements.

1. The equipment shall be manufactured by Vaughan Company, Inc., Hayward Gordon, Wemco Inc., or Landia, Inc. The design shall be shown on the Drawings is based around Vaughan Company Pump Model SE3G.
2. Pumps shall be manufactured in accordance with all applicable standards of the Hydraulic Institute.
3. Pump manufacturer shall furnish pumps, motors, and accessories as complete package to insure proper coordination and compatibility of equipment.
4. The equipment shall be manufactured in accordance with the best practices and methods, and shall operate satisfactorily when installed as shown on the Drawings.
5. The Contract Drawings are based on the mechanical equipment manufactured by Vaughan. Selection of a different manufacturer may require a revised layout. Any revision in the design and/or construction of the structures, piping, appurtenant equipment, electrical work, etc. required to accommodate such a different manufacturer shall be made at no additional cost to the Owner and be as approved by the Engineer.
6. The manufacturer supplying this equipment must have at least five installations of the same design, each with a minimum of three years successful operating experience.

1.06 SYSTEM DESCRIPTION

- A. All of the equipment included herein is intended to be standard for pumping thickened sludge surface scum and/or foam. The pumps shall operate properly (on system curves) at all hydraulic conditions indicated.
- B. The chopper pumps shall be as follows:
 1. Name: Thickener Scum Pump No. 1 - 4
 2. Location: Gravity Thickeners 1A, 1B, 2A, and 2B

3. Number of Units: 4
4. Configuration: Submersible
5. Capacity and Head: 200 gpm at 27 feet TDH
6. Minimum Efficiency at Design Capacity: 45 percent
7. Secondary Capacity and Head: 250 gpm at approximately 24 feet TDH
8. Pump Speed at Design Capacity: 1750 rpm (maximum)
9. Minimum Solids Size: 3-in
10. Minimum Shut-off Head: 34 feet
11. Motor Type: Submersible Electric
12. Motor Enclosure: Submersible, Explosion Proof
13. Motor Hp: 5
14. Pump Discharge Size: 3-in
15. Pump shall be capable of successful operation without motor overload, and without vibration at run-out.
16. Each pump will be operated at constant speed with start and stop control provided at the local control station and scum pump control panel furnished under this Section.

1.07 SERVICES OF MANUFACTURER'S SERVICE ENGINEER

- A. Provide the services of factory-trained service engineer, specifically trained on the type of equipment specified. The man-day requirements listed are exclusive of travel time and do not relieve the Contractor of the obligation to provide sufficient service to place the equipment in satisfactory operation.
 1. Start-up, testing and O&M instruction: Complete review of installation, Provide written certification that the installation is complete and operable in all respects, and that no conditions exist which may affect the warranty. Provide instruction on operation and maintenance of the equipment, including start-up, shut-down, troubleshooting, lubrication, maintenance and safety:

One 8-hour day

1.08 DELIVERY, STORAGE AND HANDLING

- A. All equipment shall be crated and delivered to protect against damage during shipment.
- B. All parts shall be properly protected so that no damage or deterioration will occur during a prolonged delay from the time of shipment until installation is completed and the units and equipment are ready for operation.

- C. All equipment and parts shall be properly protected against damage during a prolonged period at the site.
- D. Factory assembled parts and components shall not be dismantled for shipment unless permission is received in writing from the Engineer.
- E. The finished surfaces of all exposed flanges shall be protected by wooden blank flanges, strongly built and securely bolted thereto.
- F. Finished iron or steel surfaces not painted shall be properly protected to prevent rust and corrosion.
- G. After hydrostatic or other tests, all entrapped water shall be drained prior to shipment and proper care shall be taken to protect parts from the entrance of water during shipment, storage and handling.
- H. No shipment shall be made until approved by the Engineer.

1.09 MAINTENANCE

- A. One set of all special tools required for the maintenance, adjustments, and repair of the equipment shall be provided for each pump model.
- B. As a minimum, the following spare parts shall be provided:
 - 1. One set of mechanical seals.
 - 2. One complete set of gaskets and O-rings.
- C. All tools and spare parts shall be furnished in accordance with Section 01170.

PART 2 PRODUCTS

2.01 MATERIALS AND EQUIPMENT

- A. General.
 - 1. The equipment covered by these Specifications is intended to be standard submersible, explosion-proof pumping equipment of proven ability as manufactured by reputable concerns having long experience in the production of such equipment. The equipment furnished shall be designed, constructed, and installed in accordance with the best practices and methods, and shall operate satisfactorily when installed as shown on the Drawings.
 - 2. All parts shall be so designed and proportioned as to have liberal strength and stiffness and to be especially adapted for the work to be done. Ample room and facilities shall be provided for inspection, repairs, and adjustment.
 - 3. Pumps shall be installed on two-inch diameter stainless steel guide rails. Two guide rails shall be provided for each pump. Guide rail system shall be non-sparking and shall include a cast bronze pump guide bracket, cast ductile iron discharge elbow with mounting feet and 125-lb flanges, upper guide rail mounting bracket, and intermediate guide brackets every 5 feet. System design shall prevent spark ignition of explosive gases during pump installation

and removal. Under the work of this Section, the contractor shall be specifically responsible for providing and installing the guide rails and mounting the pumps and rails to the concrete vault with stainless steel expansion bolts. A stainless steel lifting cable shall be attached to the top of the pump vault and to the top of each pump assembly. The pumps shall be completely removable and able to be reinstalled without the need for personnel to enter the wet well.

4. Brass or stainless steel nameplates giving the name of the manufacturer, the rated capacity, head, speed, and any other pertinent data shall be attached to each pump.
5. Brass or stainless steel nameplates giving the name of manufacturer, serial number, model number, horsepower, speed, voltage, amperes, service factor, insulation, and all other pertinent information shall be attached to each motor. The nameplate rating for the motor shall not be exceeded, nor shall the design service factor be reduced when its pump is operating at any point on its characteristic curve.
6. The pumps and motors shall be designed and constructed to avoid the generation of objectionable noise or vibration.
7. The pumps shall be identical in every respect with all parts interchangeable and designed for the service conditions specified in PART 1.
8. The nameplate rating of the motors and drives shall not be exceeded, nor shall the motor design service factor be reduced when its pump is operating at any point on its characteristic curve.

B. Chopper Pump.

1. The pumps for the scum/foam wells shall be submersible, heavy duty, solids handling, non-clogging, chopper type pump. The pump shall be located as shown on the Drawings and as specified herein.
2. The pump casing shall be of semi-concentric design and shall be constructed of ASTM A536 ductile cast iron or ASTM A48 cast iron with 125 or 150 lb. ANSI Standard flanged suction and discharge connections. All internal case clearances shall be equal to the discharge diameter so that all material which will pass through the discharge will pass through the pump. All cast parts shall be furnished in accordance with ASTM Standards. The casing shall be provided with all necessary cleanout, vent and drain connections.
3. The impeller shall be semi-open type with pump out vanes or a partial rear shroud to reduce seal area pressure, and to draw lubricant down from the reservoir should seal leakage occur. Chopping/maceration of materials shall be accomplished by the action of the cupped and sharpened leading edges of the impeller blades moving across the cutter bar at the intake openings, with a set clearance between the impeller and cutter bar of 0.010 to 0.015-in. Impeller shall be cast from ASTM A148 Grade 90-60 alloy, heat treated to minimum 60 Rockwell C hardness and dynamically balanced. The impeller shall be keyed to the shaft with a hardened steel bolt with washer, and shall have no axial adjustments or set screws. Fabricated impellers shall not be acceptable.
4. The cutter bar shall be recessed into the pump bowl, with a funnel shaped inlet opening, and shall contain at least 2 shear bars extending diametrically across the entire pump

suction opening for the purpose of preventing intake opening blockage and wrapping of debris at the shaft area. The cutter bar shall be T1 plate steel and heat treated to minimum 60 Rockwell C hardness. Fabricated cutter bars or individually mounted shear bars shall not be acceptable.

5. The upper cutter assembly shall consist of a specially modified impeller working against a stationary cutting ring mounted into the back side of the casing in order to eliminate any buildup of rags, hair, or other stringy material, or the area behind the impeller shall be protected from fouling by the cutting and expulsion action of the serrated and sharpened teeth in the rear impeller shroud sweeping across spiral grooves in the casing backplane. The upper cutter shall be ASTM A148 cast alloy steel and heat treated to a minimum 60 Rockwell C Hardness.
6. Each motor shall be equipped with tandem mechanical seals in oil bath and dual moisture sensing probes.
7. Shaft shall be AISI 4140 heat treated steel or equal. Shaft diameter will be a minimum of 1.5-inches. Each pump shaft shall directly couple to the motor shaft with a bolt and keyway.

C. Motors.

1. Submersible motors shall be U.L. Listed, Explosion Proof for Class 1, Division 1, Group D hazardous locations, with a 1.15 service factor and Class F insulation system. Motor horsepower and synchronous speed shall be as specified herein. The motor shall be rated for 15 minutes of in-air operation at full load.
2. Motors shall not be required to deliver more than its rated nameplate horsepower, at unity (1.0) service factor, under any condition of mechanical or hydraulic loading throughout the entire pump performance curve.
3. Power cabling length shall be suitable for the pump station arrangements shown on the Drawings. Power cable shall be provided by the pump manufacturer.
4. Each pump shall be equipped with moisture leak detectors and motor thermal overload switch.

D. Pump Control Panel and Accessories.

1. The scum pump control system shall be a Type B packaged control system type as specified in Section 13390.
2. Each pump shall be provided with a Control Panel and Field Control Station, as shown on Drawings. Refer to Electrical Drawings for scum pump control panel field interconnect wiring schematic. Refer to Section 13390 for Package Control System requirements.
3. Each pump shall be provided with a submersible level transmitter meeting the requirements of Section 17380 and as shown on the Contract Drawings. Control panel shall allow operator-adjustable set point for automatic pump start, pump stop, high level alarm and low level alarm. Initial set point elevations shall be as listed in Paragraph 2.01-D.13.

4. Each pump shall be provided with an automatic recirculation valve assembly, controlled through the scum pump control panel, as specified herein.
5. The pump shall be provided with a discharge pressure gauge and annular flange mounted diaphragm seal. Refer to section 15120 for gauge and diaphragm seal requirements. Gauge range shall be 0 to 30 psi.
6. The controls for the scum pump system shall be mounted in a NEMA 4X Type 316 stainless steel enclosure provided by the pump manufacturer. Panels shall be located as shown on the Drawings. Panel construction shall meet the herein specified requirements and the general requirements of Section 13390.
 - a. Provide sun shield as specified in Section 13390.
7. The control panel shall have a hinged front door with neoprene gasket. Provide appropriate electric shock warning label on the outer door of the panel. A nameplate shall be permanently affixed to the panel and include model number, voltage, phase, hertz, ampere rating and horsepower rating of the pump.
8. Each control panel shall house the motor starter and the control relays and other devices necessary to provide the correct operation sequence.
9. At a minimum, the following controls shall be provided for each scum pump control panel system, as shown on Drawings:
 - a. Local/Manual/Off/Auto Switch
 - b. Pump Start Pushbutton
 - c. Pump Stop Pushbutton
 - d. Recirculation Assembly Recirculate/Discharge Switch
 - e. Reset
10. Complete pump control panels shall be provided for mounting and shall be completely wired and ready for field connection of power, control/sensory, and alarm wiring. The control panels shall be located at each gravity thickener as shown on the Drawings. The entire control panel assemblies shall be UL labeled for industrial control panels in accordance with UL-508.
11. Power supply to the pump control panels will be 480 Volt, 3 phase. Provide individual thermal magnetic circuit breakers/disconnect switches interlocked with the door handle. 120 and/or 24 volt control circuit transformers with fuse protection shall be included.
 - a. Control leads to and from the wet well or sump shall be low voltage, microwatt type designed such that if system components fail, voltage and current will not exceed their normal values. All of the low voltage intrinsically safe components shall be isolated by and mounted through a grounded metal barrier. All field connections shall be by means of terminals.
 - b. Panels shall have lamacoid nameplates, Hand/Off/Automatic selector switches, pump run lights, pump running elapsed time meters, a thermostatically (adjustable) controlled condensate heater, and lightning protection.
12. A local field control station shall be provided as shown on the Drawings for manual control at the pumps. The local control station shall comply with NEC requirements for a Class 1 Division 2 area. The Local switch position at the scum pump control panel shall enable control at the local field control station when the Local/Remote switch at the field control

station is in the Local position. The Remote switch position at the field control station will enable operation from the scum pump control panel. The following controls at the field control station shall be:

- a. Local/Remote Switch
- b. Pump Start Pushbutton
- c. Pump Stop Pushbutton

13. Scum Pump Control.

- a. The pumps shall be started and stopped automatically by submersible level transducer located in the scum well or manually from the scum pump control panel or local field control station.
- b. Transducer set points shall be field adjustable and initially set, as listed below, or as acceptable to the Engineer. Refer to Contract Drawings for installation requirements.
 - 1) Low Level Alarm: 428.0' or equal to minimum submergence elevation per manufacturer.
 - 2) Pump Off Elevation: 428.5' or 6" above minimum submergence elevation per manufacturer.
 - 3) Pump On Elevation: 432.0' or equal to field verified thickener scum pipe invert elevation.
 - 4) High Level Alarm: 433.0' or 12" above field verified thickener scum pipe invert elevation.
- c. Local and Remote Manual Control: When the pump Local/Manual/Off/Auto switch is in the Manual position, the pump shall be started and stopped from the pushbuttons on the scum pump control panel. When the pump Local/Manual/Off/Auto switch is in the Local position, the pump shall be started and stopped from the pushbuttons on the field control station. An Amber indicating light shall be provided on the scum pump control panel to indicate when the field control station is in the Local position.
- d. Local Automatic Control at Control Panel: When the pump Local/Manual/Off/Auto switch is in the Auto position, the pump shall be automatically started and stopped by the control panel using the level transducer located in the basin. The pump shall be called to start when the level in the wet well rises above the "Pump Start" level and shall stop when the wet well falls below the "Pump Stop" level.
- e. A Red run indication light shall be provided on the scum pump control panel to indicate when the motor is running.

14. A Pump Temperature and Leak Detection.

- a. Provide a leak and temperature detection device for each new pump.
- b. The device shall accept the following field wiring:
 - 1) The thermal detection/alarm portion of the device shall be wired to the thermal sensor in the submersible pump motor.
 - 2) The leak detection/alarm portion of the device shall be wired to the leakage sensor in the submersible pump motor.
- c. The device shall provide dry output contacts rated 120 VAC, 10 Amps for alarm of high temperature or leak detection to be used in the pump control panel circuit to shut down the motor.
- d. The device shall have indicating lights for moisture and temperature detection.
- e. An alarm reset shall be provided.

2.02 RECIRCULATION SYSTEM

- A. The scum pumps shall be fitted with an adjustable recirculation nozzle assembly to permit recirculation of the pit contents prior to discharge. The recirculation nozzle shall be adjustable minimum 180 degrees horizontally and 45 degrees vertically. A valve assembly shall be connected to the pump discharge to adjust pump flow either to the nozzle or the pump discharge flange. Valve shall be ASTM A536 ductile cast iron or ASTM A48 cast iron, with 316 SS valve disk and 150 lb. flanged recirculation and discharge flange. Automatic operation of the recirculation assembly shall be achieved through an electronic valve actuator. Manual operation shall also be permitted. The operating levers shall be located above at a mounting plate for easy access.
- B. Automatic Valve Actuator: An electrically operated valve actuator shall position the valve for pumpout or mixed operation. A ball screw linear actuator shall be used to provide valve positioning. Unit shall operate on 120V AC, single-phase power with 25% duty cycle, and shall be capable of producing 500lb. of actuation force, with a freewheeling feature to prevent over travel at the end of stroke. Unit shall be powered from scum pump control panel. External timers are required to determine valve position. A capacitor for single phase-motor starting shall be included in the design. All components shall be housed in the scum pump control panel.

2.03 ACCESSORIES

- A. Submersible level transmitter shall be as specified in Section 17380.
- B. Portable Davit Crane.
 - 1. A portable davit crane system shall be supplied to remove the pumps from the wet wells. One davit crane shall be provided and each scum pump shall be provided with a pedestal mount base so that the davit crane can be moved to any of the scum wells.
 - 2. Davit crane shall be Series 5PT10-15 as manufactured by Thern, Inc. Alternative manufacturers may be approved if requirements specified herein are met. The crane manufacturer shall have a minimum of five years of experience in providing this type of equipment.
 - 3. Davit crane shall have a pedestal base and manual operating winch. Crane shall have a design factor of greater than 3:1 for all components including the lifting winch and base.
 - 4. Crane boom reach shall telescope up to four different lengths and shall have a boom that is adjustable position between horizontal and 45 degrees from horizontal. The minimum height of the boom shall be 51 inches between mounting surface and the underside of the boom in all base configurations. Mast and boom shall be able to rotate 360 degrees with a rotational handle to facilitate rotation. Contractor and pump supplier shall field verify all dimensions and ensure that the crane can reach, lift, and move pump from wet well to ground surface (adjacent to wet well) without damaging pump.
 - 5. The crane system shall be located as shown on the Drawings and verified in the field. The crane system shall avoid conflict with pump accessories and control panel, as well as provide a clear walking area. Location shall be submitted to Engineer for approval.

6. Crane shall be made of galvanized steel and meet all applicable ASTM standards. Crane boom, mast, and base shall have a corrosion resistant finish. Hook and wire rope shall be type 304 stainless.
7. Crane shall have a minimum capacity of 550 pounds when fully extended. Contractor shall coordinate with pump supplier to confirm that pump weight does not exceed capacity of crane system.
8. Crane shall have the ability to break down into portable carrying components with no single component weighing more than 50 pounds.
9. Provide a nametag made of a non-corrosive metal that includes the manufacturer's name, model number, serial number, capacity rating, and any other necessary information.

2.04 SURFACE PREPARATION AND SHOP PRIME PAINTING

- A. All surfaces shall be prepared, shop primed and finish painted in the manufacturer's shop as part of the work of this Section. Surface preparation and shop priming shall be as specified in Section 09901. Finish paint shall be manufacturer's standard high solids epoxy. Touch-up paint shall be provided.

2.05 FACTORY TESTING

- A. Factory performance tests shall be conducted and the results submitted to and approved by the Engineer prior to shipment of the equipment.
 1. Each pump shall be tested at the factory to show satisfactory mechanical operation of the unit and hydraulic performance in strict accordance with these Specifications. Tests shall be performed in accordance with the latest edition of the Hydraulic Institute Standards. A complete test report for each pump, including characteristic curves of the pump, consisting of at least head, capacity, efficiency, and horsepower, and copies of the hydrostatic test report shall be submitted with O&M manuals.
 2. Each drive motor shall be factory tested as specified in Section 01171.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Installation shall be in strict accordance with the manufacturer's instructions and recommendations in the locations shown on the Drawings. Installation shall include furnishing the required oil and grease for initial operation. The grades of oil and grease shall be in accordance with the manufacturer's recommendations. Anchor bolts and guide rails shall be set in accordance with the manufacturer's recommendations.
- B. Submit manufacturer's certification of installation.

3.02 INSPECTION AND TESTING

- A. After all pumps have been completely installed and made ready for operation, the pumps shall be started and run and demonstrate the ability to operate without overheating of bearings and motor, and without excessive vibration.
- B. If the pump does not perform properly, corrective measures shall be taken, or pump shall be removed and replaced with a pump that satisfies the conditions specified. Each pump shall operate for a total of 24 hours before acceptance and shall operate without excessive noise, vibration or overheating.

END OF SECTION

SECTION 11364
GRAVITY THICKENER EQUIPMENT

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. Furnish all labor, materials, equipment and incidentals required to install complete and ready for operation, and field test, sludge collection, scum removal, and appurtenant gravity thickener equipment in each of the four (4) existing 50-ft diameter gravity thickeners as shown on the Drawings and as specified herein.
- B. Electric motors and power factor correction capacitors (if required) shall be furnished as part of the work of this Section and shall be in accordance with Section 01171.

1.02 RELATED WORK

- A. Concrete work is included in Series 400.
- B. Yard piping is included in Division 2 and Division 15.
- C. Metals are included in Division 5.
- D. Surface preparation and shop prime painting is included in Section 09901.
- E. Field painting is included in Section 09902.
- F. Control panels shall be furnished as part of the work of this section and shall conform to all applicable portions of Section 13390.
- G. Instrumentation and control work, except as specified herein, is included in Division 13 and Division 17. Instrumentation and controls provided in this section shall adhere to Instrumentation and Control Specifications Sections in Division 13.
- H. Mechanical piping, valves, pipe hangers and supports are included in Division 15.
- I. Electrical work, except as otherwise specified herein, is included in Division 16.

1.03 SUBMITTALS

- A. Submit, in accordance with Section 01300, copies of all materials required to establish compliance with this section. Submittals shall include the following:
 - 1. A listing of magnitudes, directions and locations of reactions applied by the equipment to the structure.
 - 2. Certified shop and erection drawings showing all important details of construction, dimensions, weld requirements and anchor bolt locations and sizes. The equipment manufacturer shall provide installation templates for anchor bolts.
 - 3. Descriptive literature, bulletins and/or catalogs of the equipment.

4. The total weight of the equipment including the weight of the single largest item or component.
5. A complete bill of materials for all equipment.
6. A list of the manufacturer's recommended spare parts. Include gaskets, packing, etc., on the list.
7. The recommended summer and winter grades of lubricants along with alternative references to equal products of other manufacturers.
8. Documentation of the AGMA rating of the drive assembly.
9. Complete data on motors and power factor correction capacitors (if required) as specified in Section 01171.
10. Complete description, control diagrams and schematics of torque overload and other instrumentation devices.
11. Submittal information shall include detailed information indicating wiring connection points for all external devices and controls as specified herein.
12. Complete description of the control panel's required components in accordance with Section 13390.
13. Detailed point-to-point wiring diagrams that show all terminal blocks and internal wire tag numbers and block wiring diagram that show number, type and size of all conductors connected externally to the control panel(s).
14. Documentation of the design torque rating of all components of the thickener mechanism.
15. Evidence of manufacturer experience as specified in paragraph 1.05.
16. A copy of the written warranty in accordance with Section 01740.
17. Submittal requirements for anchor bolts shall conform to the requirements as specified herein.
18. Submittal requirements for the preparation of concrete surfaces shall conform to the requirements of Series 400 and as specified herein.
19. Welding data including the following:
 - a. Welding procedure specification for all procedures used during fabrication.
 - b. Welding procedure qualification record.
 - c. Welder's certification for the qualified procedures.
 - d. Post-weld de-scaling and cleaning procedures.
20. ABMA Calculations: Include the following, performed and certified by a registered professional engineer. B-10 / L-10 calculations should be provided by the clarifier supplier substantiating the life rating of the main bearing. The calculations shall include:
 - a. No. of balls (Z)

- b. Total hanging weight of equipment (Ft)
 - c. Rotational speed (rpm)
 - d. Raceway hardness factor (fh)
 - e. Weibull exponent (e)
 - f. Nominal contact angle (a)
 - g. Thrust and radial raceway material factor (fcm)
 - h. Pitch diameter (dpw)
 - i. Ball diameter (dw)
- B. In the event that it is impossible to conform to certain details of this section, describe completely all non-conforming aspects.
- C. Submit certified copies of field test report as specified in PART 3.

1.04 REFERENCE STANDARDS

- A. Hydraulic Institute (HI)
- B. American Society for Testing and Materials (ASTM)
- 1. ASTM A36 - Standard Specification for Carbon Structural Steel.
 - 2. ASTM A48 - Standard Specification for Gray Iron Castings.
 - 3. ASTM A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 - 4. ASTM A148 - Standard Specification for Steel Castings, High Strength, for Structural Purposes.
 - 5. ASTM A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
 - 6. ASTM A276 - Standard Specification for Stainless Steel Bars and Shapes.
 - 7. ASTM A325 - Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength.
 - 8. ASTM A536 - Standard Specification for Ductile Iron Castings.
 - 9. ASTM A992 - Standard Specification for Structural Steel Shapes.
- C. American National Standards Institute (ANSI)
- 1. ANSI B1.1 - Unified Inch Screw Threads (UN and UNR Thread Form).
 - 2. ANSI B16.1 - Cast Iron Pipe Flanges and Flanged Fittings.
 - 3. ANSI 9 - Load Ratings and Fatigue Life for Ball Bearings.
 - 4. ANSI 11 - Load Ratings and Fatigue Life for Roller Bearings.

D. American Gear Manufacturers Association (AGMA)

1. AGMA 250.04 - Lubrication of Industrial Enclosed Gear Drives.
2. AGMA 908-B - Geometry Factors for Determining the Pitting Resistance and Bending Strength of Spur, Helical and Herringbone Gear Teeth.
3. AGMA 1012 - Gear Nomenclature, Definitions of Terms with Symbols.
4. AGMA 2001-D04 - Fundamental Rating Factors and Calculation Methods for Involute Spur and Helical Gear Teeth.
5. AGMA 2004-B - Gear Materials and Heat Treatment Manual.
6. AGMA 6001-C - Design and Selection of Components for Enclosed Gear Drives.
7. AGMA 6010-E - Standard for Spur, Helical, Herringbone and Bevel Enclosed Drives.
8. AGMA 6019-E - Gearmotors Using Spur, Helical, Herringbone, Straight Bevel or Spiral Bevel Gears.
9. AGMA 6034-B92 - Practice for Enclosed Cylindrical Wormgear Speed Reducers and Gearmotors.

E. American Institute of Steel Construction (AISC)

1. Specifications for Design, Fabrication and Erection of Structural Steel for Buildings.

F. American Iron and Steel Institute (AISI)

G. American Welding Society (AWS)

H. American Bearing Manufacturers Association (ABMA)

I. National Electrical Manufacturers Association (NEMA)

J. Factory Mutual (FM)

- K. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

A. Qualifications.

1. The Contractor shall assume responsibility for the satisfactory installation and operation of the entire system of thickener mechanisms as specified.
2. The gravity thickener equipment is intended to be standard equipment of proven ability as manufactured by a single manufacturer who is fully experienced, reputable and qualified in the manufacture of the equipment to be furnished. The manufacturer shall have furnished equipment, similar to that to be provided under this Section, for at least ten separate

wastewater facilities, each with gravity thickener(s) of the same size or larger than the gravity thickeners on this project and the equipment shall have been in continuous and successful service for not less than ten years.

3. The equipment shall be manufactured, fabricated and installed in accordance with the best practices and methods and to operate satisfactorily when installed as shown on the Drawings.
4. The equipment shall be by Walker Process; Ovivo/Eimco Water Technologies; Hi-Tech; or WesTech Engineering.
5. Should equipment which differs from this section be offered and determined to be equal to that specified, such equipment shall be acceptable only on the basis that any revisions in the design and/or construction of the structure, piping, appurtenant equipment, electrical work, and associate items required to accommodate such a substitution shall be made at no additional cost to the Owner and be as approved by the Engineer.

B. Services of Manufacturer's Representative.

1. The manufacturer shall furnish an engineer experienced in the erection, alignment and operation of the equipment furnished under this section for a minimum of two days per mechanism to supervise the erection and adjustment of the equipment, certify its readiness for operation and assist with start-up and testing. Each day shall include a full eight hour working day on the project site; travel time shall be additional to these requirements.
2. A factory representative who has complete knowledge of the proper operation and maintenance of the equipment furnished shall be provided for one day as defined above and in addition to the days required above, to instruct representatives of the Owner and the Engineer on proper operation and maintenance of the equipment. An additional trip is not necessarily required, if the training can be satisfactorily scheduled as an extension of the installation and inspection trips, as provided above; and provided that the final operational test is successful and the operation and maintenance manuals and instructions have been furnished and approved.

C. Operating and Maintenance Instructions.

1. Submit a Draft and Final Operations and Maintenance Manual to the Owner and Engineer in accordance with Section 01730. The manual shall be prepared specifically for this installation and shall include all required cuts, drawings, equipment lists, and descriptions necessary to instruct operating and maintenance personnel unfamiliar with such equipment. Furnish for review by the Owner and Engineer a draft version of the O&M Manual. Respond to Owner and Engineer comments and furnish four copies of final O&M Manual to Owner and Engineer in 3 ring binder along with digital copy in PDF format.

1.06 SYSTEM DESCRIPTION

- A. All of the equipment specified herein is intended to be standard equipment for use with either primary sludge, secondary sludge, or a combination of both. Supplemental water may be added to increase overflow rates to industry and TCEQ standards.

- B. Each gravity thickener shall be a complete assembly and shall include: center drive assembly; access bridges and walkways; center column; influent well; center drive cage; sludge collection equipment; scum collection equipment; anchors and hardware; and related equipment.
- C. The thickener units shall be installed in existing circular concrete tanks with an inside diameter of 50-ft, approximately 14 degree floor slope, and a side water depth and freeboard as shown on the Drawings. Contractor is responsible for field verifying dimensions.
- D. Each gravity thickener mechanism shall be designed to receive primary sludge, waste activated sludge, and a combination of both types of sludge, as well as supplemental water.
- E. Each gravity thickener mechanism shall be designed to receive the following hydraulic flow rates and solids loading rates:
 - 1. 1,100 gpm of sludge or a combination of sludge and supplementary water (maximum).
 - 2. 60,000 lb/day of solids.
- F. Each gravity thickener shall be able to thicken settled sludge to a solids concentration of up to 3.0 percent.
- G. Each thickener unit shall be of the under-floor, center-column feed type with peripheral weir to a peripheral weir overflow to an annular discharge launder. The center column shall support the entire mechanical drive and collection equipment and the inboard end of the access walkways which spans from the outside wall of the tank.
- H. The central driving mechanisms shall support and rotate two attached rake arms. Rake collector blades attached to the arms shall be arranged to move the settled sludge on the tank bottom to a sludge concentrator. Scrapers attached to the arms shall move the sludge to the point of withdrawal. The rake arms and collector scraper blades shall be designed to operate at a peripheral speed not to exceed 10 fpm. A scum collector shall be attached to each of the sludge rake arms to remove floating material (skimmings) from the liquid surface, for discharge into a scum box supported off of the tank effluent launder and/or tank wall as shown in the Drawings.
- I. Influent sludge shall enter through the influent pipe and discharge through openings near the water surface directly into the influent chamber at a maximum flow rate of 1,100 gpm. Flow shall then pass under the lower rim of the influent baffle (influent well) into the clarification zone and eventually discharge over the peripheral overflow weir and trough.
- J. The Contractor shall adjust the rake collector blades, squeegees, and other equipment provided to the finished contours of the gravity thickeners tank floors.
- K. Underwater bearings to carry any part of the vertical thrust load will not be acceptable. All gearing shall be completely enclosed and oil lubricated.

1.07 PROJECT/SITE REQUIREMENTS

- A. The equipment required under this Section shall be provided in accordance with the sequencing requirements specified in Section 01010. As a result, the services of the Manufacturer's Representative as specified in Paragraph 1.05B cannot occur in one continuous site visit. The specified services, including alignment, final testing and startup shall be provided for each

thickener unit at the time required by the construction sequence. Additional days required to meet requirements of these specifications shall be at no additional cost to the Owner.

- B. All of the equipment provided shall be identical and interchangeable for each gravity thickener.

1.08 MAINTENANCE

A. Spare Parts.

1. Spare parts shall be furnished with the equipment by the manufacturer in accordance with Section 01170.
2. As a minimum, the following spare parts shall be furnished for each size unit provided under this section:
 - a. One set of rake blade squeegees (for all scrapers in the tank).
 - b. One set of all gaskets, seals, sealing strips, etc., (including but not limited to neoprene lip seals or felt seals for the spur gear.).
 - c. One set of scum collector (skimmer) wiping edges.
 - d. One drive chain (if used).
 - e. One set of heat treated bearing strip liner inserts (main turntable assembly) (if used).
 - f. Twelve shear pins (if used).
 - g. All other spare parts recommended by the manufacturer as needed to replace equipment items failing due to normal wear and tear during a one-year period of operation following Substantial Completion.

B. Special Tools.

1. Provide all special tools required for normal maintenance. Tools shall be packaged in a steel case, clearly and indelibly marked on the exterior to indicate equipment for which tools are intended. Include any special equipment required to facilitate drainage or refill of lubricating oils.

PART 2 PRODUCTS

2.01 MATERIALS AND EQUIPMENT

- A. This section calls attention to certain features, but does not purport to cover all details of construction of the units.
- B. All equipment shall be assembled in the manufacturer's shop as far as practical to ensure proper fitting of parts, then match-marked for erection and disassembled for shipment. All field connections shall be bolted connections, sized and arranged to resist all static, live and erection loads. Field welded assembly shall be minimized. Photographs of test assembly shall be made available to the Engineer upon written request.
- C. The equipment shall be constructed so that there will be no chains, sprockets, bearings or operating mechanism below the liquid surface or in contact with the liquid.
- D. All structural steel used in the fabrication of the mechanisms shall be Type 304 stainless steel and shall conform to the applicable requirements of ASTM. Selection and fabrication of structural steel members shall be in accordance with the latest edition of the AISC

"Specifications for Design, Fabrication and Erection of Structural Steel for Buildings". All welding shall be continuous and conform to the latest standards of AWS. All structural steel shall have a minimum thickness of 1/4-in, except as otherwise noted.

2.02 CENTER DRIVE ASSEMBLY

- A. Provide the center drive assembly completely factory assembled and shipped as a complete unit. The basic acceptable drive types are: helical and worm gear, hydraulic gear and cycloidal reducer.
- B. The drive assembly shall consist of an electric motor connected to a primary helical or cycloidal reducer; drive and driven sprockets with drive chain (if used); an intermediate worm gear reducer (if used); pinion gear; turntable base and main spur gear; and complete automatic overload actuating system. Drive assemblies shall be completely factory assembled and shipped as complete units.
- C. The requirements for the center drive assembly construction are further described in the following.
 - 1. Design the entire drive assembly on the basis of a maximum continuous working output torque of not less than 29,000 ft.-lbs. at this maximum continuous working output torque, all gearing in the drive train shall be rated on the latest AGMA standards with a service factor of 1.0. Provide the complete drive assembly with an AGMA torque rating that includes a service factor of 1.25. This shall apply to both strength and durability with the minimum value used as the controlling limit. The main gear shall have a minimum diameter of 40 inches. With respect to the main spur gear and companion pinion, the AGMA rating shall be based on a life of 20 years continuous duty for both strength and durability. The drive assembly is to be capable of withstanding a stalled torque of twice the maximum continuous working output torque. At the stalled torque, no components of the drive train or drive platform shall be stressed to a level greater than 90 percent of yield. In addition, the unit shall be of sufficient strength to screed the 2-in of grout in the tank bottom without damage to any of its components.
 - 2. Provide drive motor of either 1,200 or 1,800 rpm, totally enclosed, for outdoor service and in conformance to the motor standards in Section 01171. The motor shall be rated for a minimum of 0.75 Hp and sized such that the nameplate horsepower rating will not be exceeded if the mechanism operates at the stalled torque.
 - 3. The primary cycloidal, planetary or helical gear reducer shall be either of the directly connected geared motor type or be separately connected to the electric motor by a flexible coupling. Gear assemblies used in the primary gear reducers shall conform to AGMA Service Classification II and have a service factor of not less than 1.4. Gears are to be supported on anti-friction bearings or directly mounted to the pinion and be oil or grease lubricated. Oil fill, drain, vent and level indicator devices or grease zerks shall be provided. Provide oil (if used) level monitoring, drainage, condensate draining and oil refill to be easily accomplished from a safe working position on the operating platform and all fittings with clear accessibility and work room. Provide oil (if used) drain extension tube as required to allow collection of drained oil and condensate into a container. Arrangements requiring auxiliary oil pumps or recirculating systems are not acceptable.

4. Provide chain drive (if used) with a minimum factor of safety of 4 as applied to the ultimate breaking or transmission strength of the chain with respect to loads transmitted at twice the maximum continuous output torque rating of the mechanism. Provide chains of the steel roller type. Fabricate sprockets from either steel or high test cast-iron. Provide chain and sprockets enclosed in a weatherproof fabricated stainless steel guard provided with service openings or equal configuration of corrosion resistant materials.
5. Provide intermediate gear reducer (if used) secured to the turntable base. The intermediate gear set shall be a cylindrical or double-enveloping worm and worm gear. The worm gearing assembly shall be supported on anti-friction roller bearings and operate in an oil bath. Provide worm gears of cast bronze or high-test cast iron either manufactured in one or two parts. If the worm gear consists of two parts, namely a rim and a spider, it is to be shouldered, bolted and doweled for concentricity. The worm shall be hardened ground alloy steel or high test heat treated cast iron. Provide the worm gearing enclosed in at least ASTM A48, Class 40 high grade cast iron housing with a removable cover over the worm. Drive configurations that utilize cycloidal or planetary reduction directly coupled to the pinion shaft do not require intermediate reduction. The output pinion shaft shall be of one or two piece construction with no over-hung loading conditions. The shaft shall be precision aligned and supported by upper and lower bearing assemblies. Suitable oil fill, drain and oil level indicator devices shall be provided. Oil level monitoring, drainage and refill is to be easily accomplished from a safe working position on the operating platform and all fittings shall be provided with clear accessibility and work room. Provide the oil drain with an extension tube as required to permit collection of drained oil into a container.
6. The turntable base shall be bolted to the center column and constructed of high test cast iron conforming to ASTM A48, Class 30A or 40 or A36 welded steel. The turntable base shall support the main spur gear; the entire rotating mechanism; and one end of the Access Bridge and walkway. The top of the turntable base shall provide or support a convenient access platform for the drive mechanism. Turntable base shall have an annular raceway for a ball race upon which the main spur gear rotates. The turntable base shall incorporate a deep oil reservoir to allow sediment to settle away from the ball race.
7. The ball race which supports the rotating mechanism shall have a diameter to assure stability (minimum 45 inches), without the need of guide shoes and shall be designed for both radial and thrust loads. The ball race shall use alloy steel balls which shall rotate on renewable hardened steel strip liners inserted in the turntable base and main spur gear or rotate locked in place by a full-contour deep groove raceway. Units utilizing full-contour deep groove raceways in the gear shall provide for replacement of the balls without removing the gear. The balls shall run in an oil bath and shall be protected by a felt or neoprene seal and a steel dust shield. Suitable oil fill, drain and level indicator devices, which can be easily read from the operating platform shall be provided. Provide oil level monitoring, drainage and refill that can be easily accomplished from a safe working position on the operating platform and all fittings with clear accessibility and work room. Provide oil drain with an extension tube as required to allow collection of drained oil into a container.
8. Provide the main spur gear of high test nodular cast iron in accordance with ASTM A536 with a minimum tensile strength of 80,000 psi or Alloy Steel AISI 4140 with a minimum ultimate strength of 120,000 psi or cast steel conforming to ASTM A148. The gear shall be driven by either a heat treated high test cast iron or heat treated alloy steel pinion gear keyed to the output shaft of the intermediate worm gear reducer or directly connected to

the output shaft of the primary cycloidal or planetary reducer. The main spur gear/bearing shall support the entire load of the rotating collector assembly from the mounting lugs.

9. Provide gear assemblies used in speed reducers or geared motors conforming to AGMA Service Classification II. All gear assemblies including the main gear and pinion used in the drive assembly shall conform to the applicable requirements of the AGMA Standards specified in Part 1 and be especially selected for the actual operating speed range of the mechanism.
10. All bearings incorporated within the drive assembly shall be of the anti-friction type, oil or grease lubricated, and conform to the following schedule of minimum rated-life expectancy (B-10) based on the ABMA standards when operating at the maximum continuous working output torque rating of the mechanism.
 - a. Main turntable and pinion bearings B10 - 200,000 hours
 - b. Intermediate Worm (if used) and wheel gearbox bearings B10 - 200,000 hour
 - c. Cycloidal or Helical and spur speed reducer gearbox bearings B10 - 30,000 hours
 - d. Geared motor (direct drive) B10 - 30,000 hours

2.03 TORQUE LIMITING DEVICES

- A. A high-torque warning, and high-high torque shut-off device shall be incorporated into the drive assembly and shall be rated for Class 1, Division 1. The device is to be actuated by the thrust from the worm shaft or rotation from the primary or intermediate gear reducer and have an indicating meter so that the load on the mechanism can be visually monitored from the platform at all times during operation. Provide assembly enclosure that is completely weatherproof and provided with access panels for field adjustment or removal of parts when necessary and 120 Volt heaters to prevent condensation. The enclosure for electrical components is to be rated for Class 1, Division 1 environment. Exposed linkage bars and moving gear housings are not acceptable.
 1. Provide the overload warning device pre-set at the factory to allow the transmission of a remote signal in case of impending excessive load. The device shall be set to energize an alarm in the case of impending excessive load of to 100 percent of the maximum continuous working output torque and motor cutout at 120 percent of the maximum continuous torque.
 2. The electrical supply to the overload device shall be 120 Volts, single phase, 60 Hz. Provide dry contacts rated 10 Amps at 120 V AC for remote control of alarms. Provide one pair of contacts for overload warning and one pair of contacts for motor shutdown, each with one normally open and one normally closed contact.
 3. Alternate means of accomplishing overload warning (such as current sensing devices) will be considered for approval providing that any revisions in electrical and instrumentation work required to accommodate such an alternate can be made at no additional cost to the Owner and be as approved by the Engineer.
- B. Shear pin device, or an additional mechanical or electronic over load device, set for 130 percent of the maximum continuous working output torque shall be furnished. Ball detent type overloads are not acceptable.

2.04 DRIVE MECHANISM CONTROL PANEL AND ACCESSORIES

- A. The gravity thickener drive control system shall be a Type B packaged control system type as specified in Section 13390.
- B. Each thickener drive shall be provided with a Control Panel as shown on the Drawings. Refer to Electrical Drawings for drive mechanism control panel interconnect wiring schematic. Refer to Section 13390 for Package Control System requirements.
 - 1. Provide sun shield as specified in Section 13390.
- C. The controls for each thickener drive system shall be mounted in a NEMA 4X Type 316 stainless steel enclosure provided by the thickener manufacturer. Panels shall be located as shown on the Drawings. Panel construction shall meet the herein specified requirements and the general requirements of Section 13390.
- D. The control panel shall have a hinged front door with neoprene gasket. Provide appropriate electric shock warning label on the outdoor of the panel. A nameplate shall be permanently affixed to the panel and include the model number, voltage, phase, hertz, ampere rating, and horsepower rating of the drive mechanism.
- E. Each control panel shall house the motor starter, control 2 relays, and other devices necessary to provide the correct operation sequence.
 - 1. At a minimum, the following controls shall be provided for each drive mechanism control panel system:
 - a. Drive Start Pushbutton.
 - b. Drive Stop Pushbutton.
 - c. Reset.
 - d. Run Indicating Light (Red).
- F. Complete drive mechanism control panels shall be provided for mounting and shall be completely wired and ready for field connection of power, control/sensory, and alarm wiring. The control panels shall be located at each gravity thickener as shown on the Drawings. The entire control panel assemblies shall be UL labeled for industrial control panels in accordance with UL-508.
- G. Power supply to the thickener drive mechanism control panels will be 480 Volt, 3 phase. Provide individual thermal magnetic circuit breakers/disconnect switches interlocked with the door handle. 120 and/or 24-volt control circuit transformers with fuse protection shall be included.
 - 1. Control leads to and from the thickener drive shall be low voltage, microwatt type designed such that if system components fail, voltage and current will not exceed their normal values. All of the low voltage intrinsically safe components shall be isolated by and mounted through a grounded metal barrier. All field connections shall be by means of terminals.
 - 2. Panels shall have lamacoid nameplates, drive run lights, alarm lights (including torque alarm), a thermostatically (adjustable) controlled condensate heater, and lightning protection.

2.05 ACCESS BRIDGES AND WALKWAYS

- A. For each thickener, an access bridge and walkway shall extend from the tank sidewall to the operating platform support on the stationary turntable base as shown on the Drawings. One end bearing member of the bridges shall slide. Each bridge shall be oriented as shown on the Drawings.
- B. The bridges and supports shall consist of structural trusses, beams or channels. Structural members shall be of Type 304 stainless steel and at least 3/16-inch thick. The walkways shall be aluminum grating at least 36-in wide inside the guardrails. Provide aluminum grating treads with integral slip resistant nosing's where steps are required. Walkways and bridges shall be designed for a super-imposed minimum loading of 100 lbs. /sq. ft. Deflection of the access bridges under this load shall not exceed 1/360 of span. The walkways surface shall be the same elevation as the operating platform to provide a uniform walkway surface.
- C. Aluminum guard railing with a 4-in toe board shall be attached to both sides of the bridges and extend around the operating platform. If a truss bridge is used, the truss sides may be designed to serve as the guard railing if equal to or greater than 3-ft 6-in high. The guard railing shall conform to OSHA requirements, to the standard details shown on the Structural Drawings for a 1-1/2-in diameter 2-rail system, and to Section 05520 with respect to materials and type of construction, line and post dimensions and spacing and strength requirements.
- D. The operating platform at the turntable base shall be of skid proof 3/8-in thick aluminum or 1/4-in Type 304 stainless steel checkered plate and shall provide a walkway space at least 2-ft-0-in wide on all sides of the drive.
- E. An electrical fixture mounting platform shall be provided on each access bridge, in accordance with the Catwalk Pole Mounting Detail included on the electrical Drawings. The mechanism manufacturer shall consider this fixture and detail in the overall bridge design and coordinate this detail design with the actual fixture furnished by Division 16.

2.06 CENTER COLUMN

- A. The center column (pier) shall be structurally sized to completely support the entire sludge collector mechanism including the inboard end of the access bridges. The center column shall be constructed from 1/4-in thick (minimum) Type 304 stainless steel plate reinforced and constructed such that no portion of the center column or top and bottom attachment flanges will be stressed beyond the allowable limits set forth in the AISC standards when the full stalled torque of the drive assembly is applied. The center columns shall have a minimum diameter of 24-in.
- B. The center column shall be mounted over the concrete influent port at the center of the tank. The bottom of the center column shall have a bolting flange for anchorage to the new concrete tank. The equipment manufacturer shall furnish a template to locate the anchor bolts for the center column. Anchor bolts shall be provided to ensure complete rigidity of the sludge collector equipment to the concrete. Two 12-in square or circular bolted inspection and access hatches shall be provided at the base of the center column. The anchor bolts shall be of Type 316 stainless steel.
- C. The center column shall have outlet ports to disperse the influent into the tanks near the water surface. The number and size of the outlet ports shall be such that the velocity of the flow in the

outlet ports shall not exceed 1.6 fps at the maximum influent flows specified in paragraph 1.06D. The top of the center column shall be provided with a mounting plate to provide an accurate fit of the drive assembly and allow the drive assembly to be accurately positioned, shimmed, leveled and grouted in place. The drive assembly shall be attached with Type 316 stainless steel bolts or machine screws.

2.07 CENTER FEED WELL

- A. The influent center feed well shall be designed to efficiently and evenly disperse the influent liquid into the tank without disturbance. The well shall be at least 10-foot diameter. The influent well shall extend at least 6-inches above the normal maximum water surface in the tank and at least 3-ft, 9-in below the water surface. The influent well shall be constructed of 3/16-in or thicker Type 304 stainless steel plate suitably reinforced with a top rim angle and vertical stiffening angles as required. The influent well shall be supported by and shall rotate with the center drive cage. Provisions shall be made for the continuous or periodic removal of scum and floating material from inside the influent well without allowing short circuiting. The above provision shall take the form of slots compatible with existing baffles.

2.08 CENTER DRIVE CAGE

- A. The center drive cage shall be of a box truss all-welded construction of structural Type 304 stainless steel having minimum plate thickness of 1/4-in. Center drive cage shall be fastened to the main spur gear assembly with Type 304 stainless steel machine screws or a high strength bolted connection. The center drive cage shall support and rotate the two collector arm assemblies complete with the influent well and scum removal devices. The center drive cage assembly shall have sufficient strength and rigidity that no member will be stressed beyond the allowable limits set forth in the AISC standards when the full stalled torque load of the drive assembly is applied as a distributed load over the length of the rake collector arm, in the forward direction. The rake arms shall be designed to have sufficient strength and rigidity to handle momentary jogs in the reverse direction. The two rake collector arms shall be connected to the center drive cage by rigid bolted connections.

2.09 SLUDGE COLLECTION EQUIPMENT

- A. Each sludge collector mechanism shall have two structural Type 304 stainless steel rake collector arms, located 180 degrees apart, and rigidly connected to the center drive cage. The rake collector arms shall be of a rectangular truss construction conforming to the slope of the tank floor and shall extend from the center drive cage to the inside face of the outer wall of the tank. Triangular truss construction is not acceptable.
- B. Each rake collector arm shall be provided with inward scraping steel blades to scrape the thickened sludge along the tank bottom to the sludge hopper located at the center of the tank. The rake arms and scraper blades shall be arranged to scrape the entire tank bottom twice per revolution of the mechanism. The rake collector blades shall have a minimum depth of 9-1/2-in and shall be of stilted construction for maximum thickening.
- C. To ensure alignment and connection to the center drive cage, the width of the rake collector arms shall be approximately the same as the center drive cage. The rake arms shall be connected to the center drive cage in such a manner that each arm can be easily removed completely or adjusted to conform to the angle of the tank floor when the tank is partially or completely

empty. Furnish shims as required to adjust rake arm angle. The arms shall not incorporate the use of tie rods or yoke connections.

- D. All blades shall be provided with adjustable Type 304 stainless steel squeegees projecting approximately 1-1/2-in below the bottom of the blade and secured by Type 304 stainless steel bolts and nuts. Each squeegee shall have a minimum thickness of 26 gauge and be designed for a 2-in minimum adjustment in the vertical plane.
- E. Components of the rake collector arms shall be constructed from 1/4-in thick (minimum) Type 304 stainless steel plate and angle, suitably reinforced such that no portion of the rake arm will be stressed beyond the allowable limits set forth in the AISC standards when the full stalled (motor cut-out) torque load of the drive assembly is applied as a distributed load on one of the rake arms.
- F. The rake collector arms shall be equipped with vertical stirring angles (pickets) attached with Type 304 stainless steel bolts to provide a sludge discharge of maximum density. The pickets shall be spaced at 2-ft on center.
- G. The sludge hopper shall be furnished with a four-blade scraper assembly as shown on the Drawings. The scraper shall be designed to continuously move accumulated sludge to the sludge withdrawal pipe. The blade settings shall be such that the concentric sludge hopper is scraped four times with each revolution of the mechanism. Each scraper blade shall be rigidly fixed to the center drive cage. Each scraper shall be constructed such that no portion of the scraper will be stressed beyond the allowable limits set forth in the AISC standards when 25 percent of the stall torque load of the drive assembly is applied.

2.10 SCUM COLLECTION EQUIPMENT

- A. Each thickener mechanisms shall be provided with two scum skimming devices to move and remove any floating scum from the entire tank water surface to a single 4-ft x 4-ft scum box as shown on the Drawings. The scum removal system shall consist of a scum skimmer blade; cantilevered support boom; truss support system; and with neoprene strips on the bottom and inner edges to seal the entrapped scum and water when discharging into the scum box.
- B. The mechanisms shall be equipped with one scum box cantilevered from the tank wall extending inward to the influent well as shown on the Drawings.
- C. The scum removal system shall consist of structural stainless steel member cantilevered from the cage and feed well. The scum removal member shall be fitted with a neoprene skirt 12-in deep by 3/8-in and fastened with steel back-up bars and stainless steel fasteners.
- D. The approach ramp of the box shall have a tapered width and sloped. The scum box shall be fabricated from 3/16-in welded stainless steel.
- E. A 6-in or 8-in Schedule 40 stub pipe connector for field fitting of a flexible connector shall be located at the inner end of the box, depending on the thickener per the Drawings. Rigid pipe connection will not be allowed. The trough shall be fully adjustable by providing a mid-adjustment leveling support and adjustable supports at the tank wall.
- F. The scum removal system shall be equipped with a mechanical flushing assembly to flush the scum box with thickener supernatant. The system shall be designed so that the skimmer boom

trips the flap gate/valve as it passes the scum box to allow water to enter. The quantity of flush water allowed, and the start of the flush cycle, shall be field adjustable using trip arms connected to the skimmer boom.

2.11 SPRAY NOZZLES SYSTEM

- A. A spray nozzles system shall be mounted to the bridge assembly as shown on the Drawings. A series of continuous spray nozzles shall be provided with a flat spray pattern.

2.12 BOLTS, NUTS, WASHERS, ANCHORS AND HARDWARE

- A. It shall be the responsibility of the equipment manufacturer to determine the number, size and location of all anchor bolts to be set in concrete. Anchor bolts, nuts and washers shall be ASTM A276, Type 316 stainless steel. Anchor bolts for field tests may be mild steel bolts. All anchor bolts shall be furnished by the equipment manufacturer.
- B. Except where specified otherwise, bolts for the equipment assembly shall be of the best-quality refined steel. Hexagonal nuts of the same quality of metal as the bolts shall be used. All threads shall be clean cut and shall conform to ANSI B1.1. Fasteners for high stressed conditions shall conform to ASTM A325.
- C. Mild steel bolts, nuts and washers shall be galvanized, or zinc-coated, after being threaded, by the hot-dip process in conformity with ASTM A123, or ASTM A153, as applicable.
- D. The equipment manufacturer shall furnish all templates for setting the anchorage.

2.13 SURFACE PREPARATION AND SHOP PRIME PAINTING

- A. Surface preparation and shop prime painting shall be part of the work of this section and shall be as specified in Section 09901. Galvanized, aluminum and stainless steel surfaces shall not require painting.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Installation of gravity thickener equipment into the existing thickener structures shall be in strict accordance with the Contract Documents and respective manufacturer's instructions and recommendations in the locations shown on the Drawings. For each thickener, the Contractor may remove the top hexagonal center of the existing domed cover and bring in gravity thickener mechanism and walkway components using the hexagonal opening, as shown on the Drawings. The Contractor may also bring in gravity thickener mechanism and walkway components through the door. The Contractor shall coordinate with manufacturer for installation.
- B. Installation shall include furnishing the required oil and grease for initial operation. The grades of oil and grease shall be in accordance with the manufacturer's recommendations. Anchor bolts shall be furnished by the equipment manufacturer and set in accordance with the manufacturer's recommendations.
- C. Submit a certificate from the manufacturer stating that the installed equipment has been examined and found to be in complete accordance with the manufacturer's requirements and

specifications, that the equipment is ready for operation and that the operating personnel have been suitably instructed in the operation, lubrication and care of the equipment.

3.02 FIELD TESTING

- A. Furnish the services of a factory representative as specified in PART 1 to inspect the final installation and supervise a test run of the equipment.
- B. Working under the direction of the manufacturer, perform field tests as follows:
 - 1. A torque test shall be conducted prior to placement of the cement mortar finish of the floors.
 - 2. Anchor bolts furnished by the equipment manufacturer shall be embedded in the concrete floor at points near the outer portion of the rake arms. The anchor bolts shall be suitable for the loads applied and shall be cut off flush with the rough concrete surface after the tests are completed. The bolts shall be arranged so that a single cable shall be used at the apex of the cables connecting panel points of the rake arms. A hydraulic cylinder of sufficient capacity with a known piston diameter, complete with pressure gauge, shall be connected to the anchor bolts to determine the horizontal load developed. The required gauge reading shall be such that the gauge indicates a force at the anchor bolts, which, when multiplied by the distance from the center of the tank to the anchor bolts, will equal twice the specified maximum continuous working output torque. This force shall be maintained for a period of 15 seconds duration to assure that the equipment is capable of withstanding the required loading under static test conditions (i.e., without the drive motor in operation) and to verify or correct the setting of the overload device prior to the actual testing of the equipment with the drive motor. Also adjust the over load warning torque setting specified in PART 2. Alternative methods of producing the required torque will be considered. Details of any alternative test procedures shall be submitted to the Engineer for approval. Test methods shall not apply impact loading or jerky loading conditions to the mechanism which may reduce the life of the equipment.
 - 3. After the above test and adjustments and settings to the overload device have been made, the drive motor shall be switched on and the mechanism loaded to overload condition to ensure that the sludge collector mechanism will alarm, then stop when a predetermined overload condition occurs in the tank.
 - 4. Upon completion of the static and operating torque tests, the mechanism shall be run dry for a period of eight hours and shall operate without vibration, noise, jamming, or overheating. Special attention shall be given during the dry test run of the equipment for the clearance of the rake scraper blades and for the operation of the scum removal device and the settings of the scum removal blade to the scum trough lip. The settings of the hinged blade to the scum box lip and the rubber wiping and sealing strips shall be such as to ensure an adequate volume of scum and effluent will be discharged once every complete revolution of the sludge collection mechanism under normal operating conditions.
 - 5. The tests shall be conducted in the presence of the Engineer. The Contractor shall furnish all power, water, equipment and appurtenances required for testing.

6. In the event the mechanisms fail to meet the above test, the necessary changes shall be made and the mechanisms retested. If the mechanisms remain unable to meet the test requirements to the satisfaction of the Engineer, they shall be removed and replaced with satisfactory mechanisms at no additional cost to the Owner.

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SECTION 13390
PACKAGED CONTROL SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. Scope of Work

1. Furnish, install, and place in service the packaged control systems as shown on the PLANS and as specified hereinafter.
2. The subsequent document entitled "Appendix A – Packaged System PLCs Programming Criteria" is hereto made part of this section and includes Owner's requirements associated with the programming of the packaged control system PLC(s) and other project requirements. Coordinate with the Owner and comply with the Owner's latest programming requirements. The contents of "Appendix A" are not inclusive of all requirements of this Contract. Refer to the PLANS and other Sections of the Specifications for additional information.
3. The subsequent document entitled "Appendix B – AWU Host Pack Spreadsheets" is hereto made part of this section and includes Owner's requirements associated with the AWU Host Pack spreadsheets. Coordinate with the Owner and comply with the Owner's latest Host Pack spreadsheet requirements. The contents of "Appendix B" are not inclusive of all requirements of this Contract. Refer to the PLANS and other Sections of the Specifications for additional information.
4. The subsequent document entitled "Appendix C – AWU Software Tagging Criteria" is hereto made part of this section and includes Owner's requirements associated with the software tagging within PLC/OIU programs. Coordinate with the Owner and comply with the Owner's latest tagging criteria requirements. The contents of "Appendix C" are not inclusive of all requirements of this Contract. Refer to the PLANS and other Sections of the Specifications for additional information.

1.02 RELATED WORK

- A. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
- B. It is the CONTRACTOR's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR's Work.
- C. Related work as called for on the PLANS, as specified herein or in other Sections of the Specifications.

1.03 QUALIFICATIONS

- A. Panels associated with the Packaged Control System (PCS) shall be designed, constructed, and tested in accordance with the latest applicable requirements of ISA, NEMA, ANSI, UL, and NEC standards.

- B. Assemble panels in equipment manufacturer's factories. Test panels for proper operation prior to shipment from the manufacturer's factory.

1.04 DELIVERY, STORAGE AND HANDLING

A. Protection

1. The Contractor, and hence the PCS supplier, shall be responsible for safety of the PCS during storage, transporting and handling.
2. At all times the PCS equipment shall be housed inside a moisture free, non-porous, extra heavy duty plastic weatherproof housing.
3. Interior and exterior of PCS equipment shall be kept clean at all times.
4. Energize the space heaters within the PCS and energize during storage and installation for humidity control.

- B. Additional project job site storage requirements: Upon delivery to the project site and prior to final installation, protect and store in accordance with the following:

1. Environmentally protected and stored in climate controlled (temperature, humidity, and non-corrosive class) environment at the job site. Size, furnish and install temporary gaseous air scrubbers, air conditioners, and additional environmental control equipment complete with branch circuiting conduit/wire as required to maintain in a controlled environment at the following conditions:
 - a. Ambient Dry Bulb Temperature:
 - 1) Minimum: 68 degrees Fahrenheit.
 - 2) Maximum: 85 degrees Fahrenheit.
 - b. Ambient Relative Humidity: Maximum: 50%.
 - c. Ambient Corrosion Level: International Society of Automation Class: G1
2. Every effort shall be made to provide all necessary electrical power connections ready for immediate connection to equipment upon arrival of equipment on jobsite.
3. Upon arrival of equipment onto job site, a maximum of ten (10) minutes shall be allowed for equipment to be left without to allow proper transition of power of equipment, especially any 120 VAC powered equipment, to ensure all air conditioning, heating, and gaseous air scrubbing equipment are fully operational with a maximum of a 10 minute down time during this transition of power.
4. Furnish and install replacement air scrubber media, air filters, etc., as required for proper operation of the environmental control equipment.

1.05 SUBMITTALS

- A. Submit shop drawings in accordance with the requirements of Section 01300 of the Contract Specifications. Include:
 1. Dimensioned/scaled top and bottom enclosure views, front enclosure elevations, and internal component/device layouts

2. One-line diagrams and wiring diagrams, as applicable,
 3. Catalog cut sheets. Include protective device coordination curves and current limiting circuit breaker/fuse peak current let through curves, where applicable. Include color chart for control panel color selection by the OWNER.
 4. Additional information as described in Appendix A – Packaged System PLCs Programming Criteria.
- B. Where Programmable Logic Controllers (PLCs) are provided as part of the PCS (refer to Section 2.03, this Section of the Specifications), submit PLC programming documentation in accordance with the requirements of Section 01300 of the Contract Specifications. Include:
1. PLC program input/output point listing, including all PLC software input/output points obtained through all serial communication interfaces. Include points obtained from the OWNER's Distributed Control System that are necessary for proper operation of the PCS. Multiple submittals of this listing will be required to facilitate the PLC programming coordination specified herein. The input/output point listing shall be provided electronically in Microsoft Excel format. At minimum, the following shall be identified in the input/output point listing for each input/output point:
 - a. Register Address: The PLC register address associated with the point
 - b. Tag Name: the tag name as assigned in the PLC program for the data point
 - c. Description: the description of the data point
 - d. Data Type: the data type as used in the PLC program (integer, floating point, etc.)
 - e. Origin. For those points transmitted via a serial communication network, the PLC identifier and its associated register address
 - f. Terminal block locations.
 - g. Additional supplementary information as recommended by the packaged control system manufacturer to enhance the understanding of the i/o listing.The input/output point listing shall be submitted along with the product data. Submittals excluding the input/output point listing shall not be accepted.
 2. Submit a Plant Control System interface table in electronic Microsoft Excel file format. The Plant Control System interface table is to consist of only those data points in the packaged system vendor's PLC data registers that are to be shared with the Owner's Top-End computer system and/or PLC system via the Modbus/TCP communication with the packaged control system PLC. This plant control system interface table should consist of ONLY points that are intended to be shared with the plant control system (Plant PLC's and plant SCADA computers). These data points should include, in particular, equipment status (e.g., on/off), process values (e.g., pressure, level, flow, etc.), equipment mode (e.g. manual/auto or lead/lag), and alarms. The table should also include control commands and setpoints (if appropriate and as deemed fit by the vendor). No other data points, e.g. internal/temporary registers, should be listed in this table. The quantity and type of input/output points to be made available to the Owner's Distributed Control System through the serial communication interfaces will be determined after Bid Award. Provide the input/output points as requested by the Owner at No Additional Charge to the Owner. The Plant Control System interface table is to consist of the following columns:
 - a. Register Address: The PLC register address associated with the point
 - b. Tag Name: the tag name as assigned in the PLC program for the data point
 - c. Description: the description of the data point
 - d. Data Type: the data type as used in the PLC program (integer, floating point, etc.)

- e. EGU Min: Minimum value for data point (for non-Boolean values). It is assumed the point is scaled to the engineering units (EGU) value in the vendor PLC for use by the plant control system
 - f. EGU Max: Maximum value for the data point (for non-Boolean values). It is assumed the point is scaled to the engineering units (EGU) value in the vendor PLC for use by the plant control system.
 - g. EGU: engineering units used (for non-Boolean values).
 - h. Bool 0 Desc: The description of the Boolean point when it is Boolean 0
 - i. Bool 1 Desc: The description of the Boolean point when it is Boolean 1
 - j. Alarm Priority: The alarm priority (for alarm points only) is to be one of H, M, or L, where H = High priority alarm, M = Medium priority alarm, L = Low priority alarm
 - k. Direction: The direction is to be one of R, W, or RW, where: R = Data is read by the plant control system from the vendor PLC, W = Data is written by the plant control system to the vendor PLC, RW = Data is read and written by the plant control system from/to the vendor PLC
 - l. Discrete Commands from plant HMI to PLC: If any discrete command bits are required from the plant HMI control system to the PLC, then the PLC will reset the command bit to zero at the end of each PLC scan. The command is to take action in the vendor PLC on Boolean 1, and have no action in the vendor PLC on Boolean 0.
 - m. All alarms shall be Boolean such that 0 is then normal condition and 1 is the alarming condition
 - n. Heartbeat Register in each PLC: For each PLC, please provide a heartbeat register that increments once every 0.1 seconds, is of Type INT and has a range of 0 to 32767
 - o. Boolean Status Points: Map all 0x (%M) register Boolean points to 4x registers (%MW) words of WORD data type and provide indexing into the 4x register to attain the Boolean value. All equipment on/off statuses shall be Boolean such that 0 = OFF, 1 = ON
3. Completed AWU Host Pack spreadsheets. The Owner will furnish Host Pack spreadsheets electronically in Microsoft Excel format. Include effort to coordinate with the Owner related with the Host Pack spreadsheets and submit the completed Host Pack spreadsheets in electronic Microsoft Excel file format. The formatting of the Host Pack spreadsheets may not be altered without prior approval from the Owner. Refer to Appendix B – AWU Host Pack Spreadsheets for additional requirements for bidding purposes.
 4. Electronic files of PLC program in editable electronic files and PDF on CD-ROM. Follow the file format as described hereinafter.
 5. Electronic files of the OIU screens in editable electronic files (Schneider Electric Vijeo *.vdz file format) and PDF on CD-ROM. Follow the file format as described hereinafter.
 6. Additional information as described in Appendix A – Packaged System PLCs Programming Criteria.
- C. Sequence of operation. In addition to the operation of the PCS, include the OWNER's process/mechanical equipment that shall also be monitored/controlled by the PCS, where applicable.
- D. Testing Related Submittals:
1. Submit ORT test procedures and test results per Section 17100.

2. Submit PAT test procedures and test results per Section 17100.

E. Certified Report: Submit a report prepared by PCS Manufacturer's technical representative certifying satisfactory installation, operation, and in service placement of entire PCS.

1.06 OPERATION AND MAINTENANCE MANUALS

A. Furnish Operation and Maintenance Manuals in accordance with the requirements of Section 01730 of the Contract Specifications. Include:

1. Installation and operation manuals.
2. Renewal parts bulletin.
3. As built drawings, including approved shop drawings.
4. Test data
5. Software program hardcopy (as applicable) for final as-built software.
6. Additional information as described in Appendix A – Packaged System PLCs Programming Criteria.

1.07 TOOLS AND SPARE PARTS

A. Furnish the following spare parts with the equipment for each PCS in conformance with the specifications:

1. One (1) – Set of fuses (minimum 3) for each type and size used for fuses 110V and greater.
2. One (1) – Set of starter contacts for every three(3) like starters used (a minimum of 1 for each size used). If contacts are not replaceable a spare starter for each size used shall be supplied.
3. One (1) - Contactor coils for every NEMA size and type starter installed, a minimum of one coil per size.
4. One (1) - Spare control relay, complete with all accessories, for each relay type used.
5. One (1) - Spare timing relay.
6. One (1) – Sets of overload heaters for each size and type used.
7. One (1) – Selector switch, complete with 2 auxiliary contacts, of each type used (two position, three position, etc.).
8. One (1) – Pilot light, complete with auxiliary contact, of each type used.
9. One (1) - Push button, complete with auxiliary contact, of each type used
10. Ten percent - terminal blocks, of each type and color used.

11. Ten percent – PLC input/output modules, with minimum of two of each module type used.
12. Ten percent – PLC CPU and Ethernet networking modules, with minimum of one of each module type used
13. Ten percent – Ethernet switches, minimum of one of each type used
14. Ten percent – OIU, with minimum of one of each type used

1.08 SPECIAL MANUFACTURER SERVICES

- A. Where PLCs are provided as part of the PCS (refer to Section 2.03, this Section of the Specifications):
 1. The PCS Manufacturer shall include, at minimum, four (4) meetings dedicated for the purpose of coordinating PLC programming development. The meetings shall be conducted to assist in the coordination effort needed to interface the PCS with the OWNER's Distributed Control System, inclusive of all the OWNER's PLCs and Top-End (host) computer system, and coordination of PCS PLC algorithm development where required to achieve the overall functional requirements of this Specification. The PCS Manufacturer shall provide a non-sales type representative to attend each meeting who is also intimately familiar with the PLC programming of the PCS. For bidding purposes, each meeting shall have a four hour duration and be held at the Owner's project site. At each meeting, the PCS Manufacturer shall also provide a submittal of the PLC program input/output point listing, sequence of operation, and electronic files of the PCS PLC program developed to date. Refer to the Submittals section of this Specification for minimum composition of input/output point listing, sequence of operation, and electronic PLC program files. The PCS Manufacturer shall include all necessary travel, submittal reproduction, and miscellaneous other expenses associated with their meeting attendance.
 2. PLC software registers associated with the input/output point types (i.e., discrete input, discrete output, analog input, analog output) that are telemetered to the OWNER's distributed control system shall be organized contiguously among each input/output point type.
 3. In the software programming, adhere to the software tagging as described in "Appendix C – AWU Software Tagging Criteria" to the extent practicable. Coordinate software tagging with the Owner.
- B. Furnish the services of a qualified, experienced, factory trained technical (non-sales type) representative to advise the Contractor in the installation of the equipment and assist in all PCS testing and start-up. Include checking alignment of parts, wiring connections, operation of all panels, parts (relays, starters, PLCs, etc.). Include time to correct and recheck any discrepancies which are discovered. Also include providing the OWNER with a report certifying that the equipment was installed, properly tested, and set in accordance with the PCS manufacturer's requirements and is in satisfactory operating condition. Format and quantity of reports shall be per the requirements of Section 01300 of the Contract Specifications.
- C. Any problems encountered with the operation of equipment, parts, components, etc. installed within the PCS shall be repaired/remedied by the manufacturer's technical representative.

- D. Prepare a harmonic study, and a coordination study of the PCS as described below.
1. The characteristics of the main PCS protective device that are most suitable for the system in providing proper protection and coordination shall be determined. The Manufacturer shall furnish the protective device of the appropriate characteristics that shall be the most suitable for the proper protection and coordination of the system.
 2. The Manufacturer shall select, set, and adjust the load side devices served by the main PCS protective device. Manufacturer's technical representative is to set, adjust and test all circuit breakers, relays, motor circuit protectors, etc. in the presence of a representative of the OWNER.
 3. For VFD applications only: Comply with the VFD Harmonic Performance Requirements of IEEE 519. The VFD Harmonic Performance Requirements shall be met at the main power supply terminals of the PCS, i.e. the point of interface between the PCS and the Owner's power distribution system field interconnect wiring. The interface point shall be located inside of the PCS Control Panel.
 4. Provide the OWNER with a test report certified by the manufacturer. Include a record of all settings. Format and quantity of reports shall be per the requirements of Section 01300 and 01730 of the Contract Specifications.

PART 2 PRODUCTS

2.01 GENERAL

- A. Furnish and install all necessary components and wiring for a complete and functional system. Furnish and install additional requirements as follows:
1. Furnish and install the enclosure as hereinafter specified. Mount and wire all components inside of enclosure unless specified otherwise. The enclosure, with all components mounted and wired, complete with all accessories, shall be referred to hereinafter as the Control Panel.
 2. Furnish and install the Control Panel configured for single point electrical feed that terminates on a dedicated main circuit breaker inside of the Control Panel. Refer to the PLANS and also the appropriate Division 11 Specification for which the PCS is provided for voltage and phase requirements. The Control Panel shall contain all necessary means, i.e. , control power transformer with primary and secondary short circuit protection/disconnects, uninterruptible power supply, associated wiring, short circuit protection, etc. to derive and distribute the needed control power at the necessary voltages for the entire PCS.
 3. Furnish and install the control system Type as hereinafter specified.
 4. Furnish and install motor starters/drives as specified herein, by other Sections of the Specifications, and the PLANS. Size, furnish, and install motor starters/drives complete with all accessories as specified.
 5. Furnish and install circuit breakers for branch circuits distributed from Control Panel as hereinafter specified. Coordinate operation of branch circuit breakers with corresponding

main circuit breaker for proper circuit isolation and protection. Note, the main circuit breaker for the control panel per paragraph 2.01.A.2 shall not be considered a branch circuit breaker for the purposes of this Specification.

6. Furnish and install field devices that are fully corrosion resistant, water tight, and resistant to all chemicals associated with the process application. All field devices life cycle, operation, and accuracy shall not be affected by the process application. As a minimum, all field devices shall be U. L. Listed and NEMA 4X rated. The mounting arrangement shall include provisions to enhance operation and maintenance of the system in consideration of the process application.
7. Where devices are required for the functional operation of the PCS but are not specified under Division 17, furnish and install manufacturer's standard.
8. For additional construction notes and special requirements, refer to the PLANS and the Specifications.

B. Analog, Control, and Alarm Signaling Requirements

1. Refer to the PLANS and also the appropriate Division 11 Specification for which the PCS is provided for minimum contacts to be connected to the OWNER's Distributed Control System.
2. All control and alarm circuits shall be 120 volts A.C. Alarm signal contacts shall open to alarm and shall be isolated contacts rated for 5 ampere at 120 volts A.C.
3. The contact configuration (normally open/closed) required for proper interface to the OWNER's Distributed Control System shall be furnished and installed at No Additional Cost to the OWNER. Under no circumstances shall contacts of pushbuttons and selector switches shall be connected to the OWNER's Distributed Control System via interposing relays. Refer to Section 17600 for minimum interface requirements to the OWNER's Distributed Control System.
4. All analog signals shall be 4 to 20 mA DC. Use "two-wire" type circuits where possible. Furnish and install loop current isolators for each analog signal circuit in which either the field device or Control Panel is located outdoors. Loop current isolators shall be per Section 17200.
5. All RTD signals shall be 100 ohm platinum type.

C. Selector Switches, Pilot Devices, Pushbuttons requirements:

1. For NEMA 12 rated enclosures: Furnish and install per Section 17200.
2. For NEMA 4X rated enclosures: Furnish and install per Section 16540.
3. Mount on enclosure door.

D. Wiring: Furnish and install as specified in Section 17200. Group conductors and route in wireways as specified in Section 17200. Wiring for 480 VAC circuits shall be per Section 16200.

- E. Identification: Tag enclosure, terminal blocks, and devices (mounted interior and on the face of the enclosure) as specified in Section 17200. Tag all wiring per the requirements of Section 16200.
- F. Grounding: Furnish and install grounding per Section 17200.
- G. Miscellaneous Accessories:
 - 1. Furnish and install lugs/ power distribution blocks /terminal blocks as required for the connection of the field wiring. Furnish and install terminal blocks per Section 17200. Furnish and install the necessary means for the termination of the field wiring at No Additional Cost to the OWNER.
 - 2. Furnish and install a Type 2 surge protective device for the 120 VAC package control system control power circuitry. Wire, and mount inside the enclosure.
 - 3. Furnish and install 24 volts DC power supply and all other power supplies per the PCS manufacturer's requirements where not specified per Section 17200. Wire and mount inside the enclosure.
 - 4. Where an uninterruptible power supply is needed for the application, furnish and install per Section 17200. Packaged control systems having PLCs shall also be furnished with uninterruptible power supplies per Section 17200.
 - 5. Arrange the enclosure internal components to coordinate with the OWNER's conduit entry requirements at No Additional Cost to the OWNER.

2.02 CONTROL PANEL ENCLOSURE REQUIREMENTS

- A. Enclosure shall be the totally enclosed, dead front, suitable for back-to-wall mounting. Free standing and wall mounted enclosures may be used. Enclosure shall be adequately sized to contain all of devices required for the PCS in addition to facilitating the termination and routing of all associated PCS field interconnect conduit/wire systems.
- B. Unless specifically noted otherwise elsewhere, enclosures shall be rated NEMA Type 4X, Type 316 Stainless Steel enclosures.
- C. Enclosure shall have hinged, gasketed doors. Each door shall have an operating handle. At minimum, Furnish and install quarter turn door latch. Furnish and install three point door latch where available for the enclosure. Furnish and install pad locking means for the door/handle.
- D. Enclosures shall have a flange mounted variable depth or cable type disconnect operating mechanism for operating the main circuit breaker. Provide padlockable disconnect operating handle located exterior to the enclosure. Handle shall be mechanically interlocked with the door to prevent personnel from opening the door when the unit disconnect is in the ON position. Furnish and install handle-door interlock defeating (bypass) feature. Disconnect operating mechanism shall be as manufactured by Square D Class 9422 or approved equal.
- E. When sizing the enclosure, consideration shall be given to the enclosure installation location and the environmental aspects associated with the location (indoors, outdoors, etc.). Enclosures shall be sized to adequately dissipate heat generated by the equipment contained therein.

Enclosures shall be provided with the necessary climate control devices, i.e. air conditioners, cooling fans, thermostatically controlled heaters, as required, for proper PCS operation. All outdoor located enclosures containing PLCs shall have air conditioners as hereinafter specified.

- F. Furnish and install interior backpanels and sidepanels as required to facilitate interior device mounting. Panels shall be painted white.
- G. Within the enclosure, designate a region for the 480Vac power distribution sub-components (i.e., circuit breakers, starters, control power transformer, etc.) and locate within proximity to one another. Furnish and install a barrier to segregate the 480Vac power distribution region from the remainder of the panel components.
- H. The following are required for enclosures containing PLCs:
 - 1. Air Conditioner:
 - a. Sizing and Quantity: Provide the size and quantity of units as required for the application environment.
 - b. Type: Thermostatically controlled packaged closed-loop air conditioner climate control unit surface mounted to the exterior side of the control panel. Suitable for use in an outdoor corrosive environment and also rated Class 1 Division II.
 - c. Material: Nema 4X, Type 316 Stainless Steel enclosure suitable and rated for use in corrosive environment, 16-gauge minimum thickness. Internal components shall be coated for corrosion protection.
 - d. Electrical Service: Connect to the PCS single point electrical service via a dedicated circuit breaker.
 - e. Controls:
 - 1) Provide air conditioner manufacturer's standard air conditioning system package control system for the air conditioner. The air conditioner shall have the capability to be controlled by the industrial thermostat specified hereinafter.
 - 2) Each air conditioner shall include low ambient controls to allow the unit to operate down to 0 degrees Fahrenheit ambient conditions.
 - 3) Provide a dedicated thermostat for each air conditioner. The thermostat shall be per Section 17200. The thermostat for each air conditioner unit shall be mounted inside the cabinet.
 - f. Accessories:
 - 1) Condensate Management System: Each air conditioner unit shall have a condensate management system that evaporates moisture from the enclosure into the condenser air stream and shall not require disposal of liquid condensate and shall not cause build-up or spillage of liquid condensate.
 - 2) Air filters: Field replaceable aluminum filters.
 - 3) Extension frame with self-contained Drip Pan Tray
 - 4) Mounting gaskets and hardware for a complete installation
 - 5) Reinforce the cabinet enclosure as required to support the air conditioner.
 - 2. Cabinet Interior Insulation:
 - a. General:
 - 1) Provide insulation for interior of cabinet to the extent practicable to reduce heat transfer.
 - 2) Install in accordance to manufacturer requirements, minimize the number of duct board sections and provide no gaps between sections

- 3) Install with cleanable aluminum foil (FRK) facing on exposed surface such that no bare fiberglass surface is exposed or visible. Install panels and other equipment onto cabinet such that insulation is not compressed.
 - 4) Securely fasten duct board onto cabinet interior surface with adhesive with 100 percent coverage of adhesive at board fiber side contact with cabinet inner surface area.
 - 5) Where heat dissipating device or other device is mounted onto cabinet panel, provide a 1-inch gap between duct board and device or as required to allow proper operation of device per device manufacturer requirements.
 - 6) Neatly cut duct board to provide a clean finished appearance.
 - b. Material: 1-inch thick fiberglass duct board having a rigid resin bonded and flame retardant fibrous glass board with a damage-resistant reinforced aluminum foil (FRK) facing
 - c. Thermal Conductivity: (K at 75 degrees Fahrenheit) no greater than 0.23 BTU-inch per hour foot-squared degree Fahrenheit.
 - d. Adhesive, tape, and duct board installation shall comply with NFPA 90A or NFPA 90B and UL 181A and ASTM C 916.
 - e. Manufacturer: Owens Corning series QuietR or approved equal
 - f. Accessories:
 - 1) Tape: Aluminum foil / scrim / kraft (FSK) 3-inch minimum width non-tearable with diamond patterned backing, a rubber based adhesive system, and shall meet requirements of UL 723 and as manufactured by Shuretape or approved equal.
3. Space Heater:
- a. Sizing and Quantity: Provide the size and quantity of units as required for the application environment.
 - b. Type: Thermostatically controlled. Provide a dedicated thermostat for the space heater. The thermostat shall be per Section 17200. The thermostat shall be mounted inside the enclosure.
4. Interior Enclosure Ambient Air Temperature Transmitter: Furnish and install an ambient temperature transmitter inside of the enclosure to monitor the interior cabinet ambient air temperature. Transmitter shall be per Section 17380. Although not shown on the PLANS, connect the 4-20mADC analog output from the transmitter to the packaged control system PLC for remote monitoring by the Owner's Distributed Control System.
- I. Furnish and install the following additional accessories for each enclosure:
1. For each door:
 - a. Grounding bonding jumper.
 - b. Door stop kit .
 - c. Door data pocket.
 2. For free standing enclosures:
 - a. Furnish and install light fixture per the requirements of Section 17200.
 - b. Furnish and install wire convenience receptacle per the requirements of Section 17200.
 - c. Furnish and install lifting eyes.

3. Furnish and install a 316 stainless steel sunshield shielding the top, sides and back of the panel. The sunshield shall also provide shielding for the front mounted devices on the enclosure. Submit data for each sunshield for Owner approval.
4. Furnish and install all additional enclosure accessories, mounting hardware, 19 inch rack accessories, etc., as required for a functional PCS.

J. Enclosures shall be as manufactured by:

1. Wall mounted: Hoffman Concept Stainless Steel 4X Disconnect Wall Mounted Enclosure Series, or approved equal.
2. Free Standing: Hoffman Stainless Steel Heavy Duty Free-Standing Type 4X Enclosures For Flange Mount Disconnects, or approved equal.

2.03 PACKAGED CONTROL SYSTEM TYPES

A. The PCS shall use one of two types of control system types to implement the packaged control system functionality as follows:

1. Type A: At minimum, this type shall employ the use of PLCs as described hereinafter. PLCs in combination with hardwired relay logic may be used at the PCS Manufacturer's discretion.
2. Type B: This type shall only employ the use of hardwired relay logic. This control system type shall not include the use of PLCs whatsoever. Additionally, any type of micro-processor based programmable relay, any relay requiring software download, or any other type of similar programmable relay shall not be used. As technology advances over time, similar appearing devices are subject to review and approval by the OWNER after Bid Award and the PCS Manufacturer shall incorporate the OWNER's request at No Additional Cost to the OWNER.

B. Additional requirements for Type A systems only:

1. General:
 - a. The type of PLC (Type 1 or Type 2) as hereinafter specified shall be selected by the PCS Manufacturer to meet the functional requirements of this Specification and also the appropriate Division 11 Specification for which the PCS is provided. Additional types of PLCs beyond those listed here shall not be accepted.
 - 1) Type 1: Furnish and install Type 1 PLCs as specified in Section 17600.
 - 2) Type 2: Furnish and install Type 2 PLCs as specified in Section 17600.
 - 3) Type 3: Furnish and install Type 3 PLCs as specified in Section 17600.
 - b. All equipment shall be furnished and installed complete with all necessary software.
 - c. As a minimum, the PCS shall communicate with the equipment as shown on the control system architecture, in addition to the Owner's Top-End computer system. Program the PCS accordingly.
2. Operator Interface Unit (OIU):
 - a. Type 1: Furnish and install Type 1 OIU as specified in Section 17600
 - b. If a specific type of OIU is not shown on the PLANS or Specifications, the default type shall be Type 1.

- c. Furnish and install the additional quantities of OIUs as may be required by the PLANS or Specifications.
 - d. Mount OIU on enclosure door, providing additional enclosure accessories (window kit, etc.) as needed to achieve appropriate NEMA rating.
3. Miscellaneous:
- a. Furnish and install the Ethernet switches, patch panels, and related hardware/accessories as specified in Section 17600 and as shown on the PLANS to facilitate the network data connections of the PCS to the OWNER's Distributed Control System.
 - b. Furnish and install additional 25 percent excess capacity over the number of inputs, outputs, and other necessary functions.

C. Requirements common to Types A and B systems:

1. Refer to the PLANS and also the appropriate Division 11 Specification for which the PCS is provided for the control system type.
2. Furnish and install relays as specified in Section 17200.

2.04 MAIN AND BRANCH FEEDER CIRCUIT BREAKERS

- A. Furnish and install thermal magnetic molded case circuit breakers. Size per NEC. Circuit breakers shall have U.L. listed minimum RMS symmetrical short circuit current rating equal to or greater than that of the bus serving the equipment, unless noted otherwise on the PLANS or in the Division 11 Specifications. Unless shown otherwise, the minimum RMS symmetrical short circuit current rating shall be 42kA at 480 volts A.C.
- B. Furnish and install where specifically shown on the PLANS or for proper circuit protection/coordination:
1. Current limiting circuit breaker.
 2. Electronic trip attachment. Trip unit shall be solid state type with field adjustable long time, short time, ground fault and pick up settings.

2.05 COMBINATION MOTOR STARTERS AND VARIABLE FREQUENCY DRIVES

Furnish and install per the following requirements.

1. General:
 - a. Comply with the control logic requirements of the PCS manufacturer.
2. Circuit breakers:
 - a. Shall have U.L. listed minimum RMS symmetrical short circuit current rating equal to or greater than that of the bus serving the equipment, unless noted otherwise on the PLANS or in the Division 11 Specifications. Unless shown otherwise, the minimum RMS symmetrical short circuit current rating shall be 42kA at 480 volts A.C.

3. Starters:
 - a. Starters shall be magnetic type, NEMA rated, with 120 volts A.C. operating coils. International type starters (IEC rated), will not be accepted, even if the starters were to show equivalent NEMA ratings.
 - b. Size and configuration (full voltage non-reversing, full voltage reversing, reduced voltage solid state, etc.) as shown on the PLANS.
 - c. Provide each starter coil with the manufacturer’s standard transient voltage surge suppression module.
 - d. Provide auxiliary contacts as required by the PLANS. Contacts shall be rated for 120 volts A.C and shall satisfy the requirements of the PLANS. Provide each starter with one (1) normally open auxiliary contact wired to terminal blocks over the number of contacts required by the PLANS.

4. Variable frequency drive:
 - a. Each Variable Frequency Drive (VFD) assembly shall consist of a main circuit breaker, VFD Controller and power section, and main output isolation contactor as shown on the PLANS. The minimum output current of the VFD shall be as shown on the one-line drawings in the PLANS.
 - b. Micro-processor based controller equipped with the manufacturer’s standard features for protection, operation, and data acquisition of a VFD system. The operation of the controller shall also be coordinated with the operation of the motor protection and management relay specified hereinafter. Additionally, furnish the features as shown on the PLANS.
 - c. Electrically interlocked with the Main Output Contactor/Starter previously specified.
 - d. Pulse Width Modulated (PWM) design converting the utility input voltage and frequency to variable voltage and frequency output. The manufacturer shall supply 18-Pulse bridge rectifier design, at minimum. UL 508C tested.
 - e. Incomplete sequence protection of each VFD main output contactor shall be provided with interlocking circuitry to fault the VFD should the contactor fail to close when commanded.

f. Provide with ratings as follows:

| | |
|--|---|
| Ambient Temperature Range: | 0 to 40 degrees Celsius |
| Input Voltage: | 480 plus or minus 15 percent VAC |
| Input Voltage Frequency: | 60 Hz plus or minus 2 percent |
| Displacement Power Factor: | Not less than 0.975 lagging under any speed or load condition |
| Efficiency at full load: | 95 percent or greater |
| Overtorque Capacity for Constant Torque Operation: | 150 percent for 1 minute |
| Overtorque Capacity for Variable Torque Operation: | 110 percent for 1 minute |

- g. Drive family (Constant torque, variable torque, etc.) to be selected by the Division 11 equipment manufacturer.
- h. The VFD minimum output current shall be as determined by the Division 11 equipment manufacturer.

- i. VFDs serving motors smaller than 15 horsepower may be 6 pulse in lieu of 18 pulse, provided the harmonic performance requirements at the terminals of the packaged control system are not violated.
5. Control Power Transformer:
 - a. Serve starter control power from PCS control power distribution per the manufacturer's standard.

PART 3 EXECUTION

3.01 FACTORY INSPECTION AND TEST

- A. Each control panel shall be completely assembled, wired, and adjusted at the factory and shall be given the manufacturer's routine shop test and any other additional operational test to insure the functionality, workability and reliable operation of the equipment.
- B. Size, furnish and install the overload relay heaters based on actual motor nameplate current. Set overload relay settings at maximum values permitted by the NEC 430-32.
- C. Size, furnish and install the motor space heater fuses based on actual motor space heater load current.

3.02 FIELD INSTALLATION (BY CONTRACTOR)

- A. Mount all PCS subcomponents as shown on the PLANS and as recommended by the PCS manufacturer.
- B. All field wiring shall be tagged per the requirements of Section 16200. Secure wiring in control panel with plastic ties. Arrange wiring neatly, remove surplus wire, and install abrasion protection for wiring passing through holes or near edges of sheet metal.
- C. Clean and vacuum all interior of the equipment. Touch-up and restore damaged surfaces to factory finish.

3.03 FIELD TESTING

- A. After field installation of the PCS and prior to energizing any of the process/mechanical equipment controlled by the PCS:
 1. Conduct an ORT for the PCS per Section 17100. Submit test results for review and approval. Prior to conducting the ORT, meet all prerequisites associated with conducting the ORT as described in Section 17100. The Owner may elect to witness the ORT. Coordinate with the Owner accordingly.
 2. Conduct a PAT for the PCS per Section 17100. Submit test results for review and approval. Prior to conducting the PAT, meet all prerequisites associated with conducting the PAT as described in Section 17100. Exception: As the application software for the PCS is provided by the PCS manufacturer, the PCS manufacturer shall lead the PAT software test activity.

3.04 MEASUREMENT AND PAYMENT

- A. No separate measurement or payment for work performed under this Section. Include cost of same in Contract price bid for work of which this is a component part.

END OF SECTION

APPENDIX A – PACKAGED SYSTEM PLC PROGRAMMING CRITERIA

PART 1 PACKAGED SYSTEMS PLC PROGRAMMING CRITERIA

1.01 GENERAL

- A. PLC Hardware to be used by packaged equipment Vendor shall be as specified in the contract bid specifications. As a minimum, the processor used to interface to the Owner's SCADA system shall support the Schneider Electric Unity Pro programming software.
- B. Vendor shall use latest version of Schneider Electric Unity Pro programming software, unless otherwise directed by Owner.

1.02 PROGRAM ORGANIZATION AND STRUCTURE

- A. The overall program shall be broken down into meaningful sections of code related to the operations of the equipment. As a minimum, include the following program sections:
 - 1. Communications - All registers that are being written to or being read from the Vendor's package system PLC from the Owner's SCADA equipment shall be grouped into one section of the program. Register addresses used for interfacing to Owner's SCADA system shall be placed in a contiguous block of registers to facilitate read and write operations
 - 2. Section Control - (if code includes variables to enable/disable sections of code).
 - 3. Process Control - If the process is complex and/or the section is very large, this section should be further broken down into permissive section(s), alarming section(s) and control section(s).
 - 4. Input/Output (I/O) Processing – This section includes data manipulation of physical inputs and outputs such as analog scaling, totalizing, etc.
 - 5. PLC Time Synchronization and Heartbeat – This section shows the registers that are to be used to synchronize the PLC's clock with the Owner's SCADA system and to determine whether the Vendor's PLC logic is executing (heartbeat) to be monitored by the Owner's SCADA system.
- B. Vendor is to follow the Owner's software tagging convention for all tags being read from or written into by the Owner's SCADA system. If the Vendor elects to use their own software tagging convention in their programs that control the equipment within their own package system, then the PLC(s) that is used to interface with the Owner's SCADA system needs to include a set of registers that will be labeled with the Owner's software tagging convention and be "mapped" to the corresponding set of registers that are used by the Vendor's software program. The mapping of these registers is to be clearly labeled in the program and indicated on the Field I/O spreadsheet to be provided at the end of the job.
- C. All program sections are to be clearly labeled with text that describes what the section of code does. As a minimum, include the key wording for each section as described above.

- D. Provide comment lines within the sections of code to describe what the various parts of the section do, especially for those areas where the function is performing is not evident or is complex to follow.
- E. All software tags in the program are to follow a structured naming convention and be clearly labeled with meaningful text descriptions to make it easy to understand what the tag represents and what function it is performing in the program.
- F. Ensure that none of the programs developed have security controls enabled, i.e. password protection on DFB's, restrictions on uploading or editing program, etc.

1.03 PROGRAM DETAILS

- A. Vendor is to use IEC programming languages supported by Unity Pro, and in general adopt the following guidelines.
 - 1. Use Derived Function Blocks (DFB) language as much as practical to standardize on process control functions.
 - 2. Use Structured Text (ST) language for Calculations and I/O Mapping routines.
 - 3. Use IEC Ladder Logic (LL) and Function Blocks (FB) for control logic and to include in DFB's.
- B. Standardize the program sections and program elements (DFB, ST, etc.) as much as possible into modular and/or functional pieces of code for repetitive and often use sections of code to simplify the program and minimize its size.
- C. Vendor is to set up a Custom Library for standard program elements like DFB's and FB's.
- D. Use Topological (Unity Pro) Addressing on both Quantum and M340 PLCs for registers associated with physical I/O, i.e. %I1.3.2 and %Q1.4.3, instead of State Ram addressing (%M) since State Ram addressing convention does not reference the physical I/O location, but topological addressing does.
- E. Use eBool variables if there may be a reason to keep track of previous values (history) or there is a need to look at a leading or falling edge in the signal.
- F. Avoid using IEC BMDI function blocks on any of the PLC programs since Unity Pro is not able to search for registers contained within the range of that block.
- G. Use IO Scanner for communication between PLC's where possible to facilitate the set-up and troubleshooting of registers that are being moved from one PLC to another.
- H. Code should be designed to avoid using force bits for the logic to execute properly. Inadvertent un-forcing of bits will cause the program behave unexpectedly.
- I. Do not initialize %MW values during a cold start or a program download. Doing so can cause stored values such as run time to be over written. Ensure this option is unchecked in the programming software if the option is available.

1.04 DOCUMENTATION AND DELIVERABLES

- A. As part of their Operations and Maintenance Manual, Vendor is to include, but not be limited to the following:
 - 1. Control Narratives that include:
 - a. The various control modes of operation; i.e. remote automatic, remote manual, local automatic, local manual, maintenance mode, etc.
 - b. Identification of and description of all permissive and shutdown signals that are required to operate the equipment or that will shut the equipment down.
 - c. Identification of all set points and process variables that are Operator adjustable with a description of what they do and how they affect the operation of the equipment.
 - 2. Field I/O and Host Pack and Peer to Peer spreadsheets (provided by Owner) to document the various software tags associated with the package equipment.
 - 3. Instrument Index spreadsheet showing all instrumentation on their package equipment and calibration information including, but not limited to; instrument tag name, input range, units, control loop description, scaling, trip set points, etc.
- B. Vendor is to provide a copy of all program files installed in the production system and source files of all documentation listed above.

END OF APPENDIX A

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APPENDIX B – AWU HOST PACK SPREADSHEETS

PART 1 AWU HOST PACK SPREADSHEETS

1.01 FIELD I/O LIST DESCRIPTIONS NOTES

A. General

1. The Field Input/Output (I/O) lists only inputs or output connected to process control equipment and devices, i.e. instrument, electrical equipment, etc.. It does not include logical inputs or outputs that are generated as part of the RTU/PLC program to do data manipulation, or data that is passed on to another controller or Host computer.
2. All inputs and outputs associated with a PLC/RTU, i.e. physical and logical points, are shown on the HostPack list if they are being transmitted/received by a Host computer, or are shown in the Peer to Peer Data Communications List, if the values are being shared with another peer device.

B. Lifted and updated from SAR SIDG.

1. RACK NAME - The rack name as shown on the contract drawings. Note this name is for cross-reference only. The actual drop, and rack number used in the software configuration will be as specified in the DROP, and RACK column of the Field I/O List.
2. FIELD DEVICE TAG - The name of the end device, in accordance with the INFOR (maintenance management system) naming convention and tagged in the field and/or on the contract drawings. This field is used as a cross-reference to the Host Pack table.
3. DESCRIPTION - The description of the signal. This description shall be used consistently throughout the application software.
4. CARD/MODULE TYPE - The Modicon model number located in the corresponding slot.
5. POINT TYPE - The point type indicates AI, AO, DI, or DO for analog input, analog output, discrete input, or discrete output, respectively.
6. DROP, RACK/BASE – The drop and rack number associated with the chassis. These fields define the required drop, rack assignment for the configuration of each chassis associated with the processor.
7. SLOT - This field defines the physical location of the module within a given chassis.
8. I/O POINT – This field defines the specific point on the module.
9. CARD/MODULE TERMINALS – Physical wiring termination points on the I/O card/module.
10. FIELD I/O ADDR. - The software register address where the I/O module places the data for the point. This field is used as a cross-reference to the Host Pack table.

11. BIT NO. - The bit within the register address where the I/O module places the data for the point, as required. This field is used as a cross-reference to the Host Pack table.
12. EGU LOW - The value of the signal at 4 mA in the specified engineering units. This information is only applicable to analog signals.
13. EGU HIGH - The value of the signal at 20 mA in the specified engineering units. This information is only applicable to analog signals.
14. EGU - The engineering units for the analog signal. This information is only applicable to analog signals.
15. SCALED IN PLC? – Defines whether or not the analog value is scaled in the PLC, or if scaling occurs at the top end. This information is only applicable to analog signals.
16. RAW LOW - The value of the signal at 4 mA in counts as written to the PLC register by the I/O module. This information is only applicable to analog signals.
17. RAW HIGH - The value of the signal at 20 mA in counts as written to the PLC register by the I/O module. This information is only applicable to analog signals.
18. SIGNAL TYPE – Electrical characteristics of the signal, i.e. 4-20 mA, 1-5 VDC, etc.
19. TERMINAL BLOCK - The name of the block of terminals where field wiring is terminated.
20. TERMINAL NO'S - The terminal numbers within the terminal block where the field wiring is terminated.
21. LOOP DIAG. – The number of the drawing where a loop drawing is shown for the signal loop. These could either be loop-specific drawings, or typical loop drawings.
22. P&ID No. – The number of the P&ID drawing where the I/O point is shown on the drawings.
23. NOTES - Miscellaneous notes to further describe the signal. This field contains information such as square root (SQRT) for analog inputs, analog alarm setpoints, shelf states for discrete inputs, etc.

1.02 HOSTPACK FIELD DESCRIPTIONS NOTES

A. General Information

1. Physical Inputs and Outputs (I/O) refer to connections to instruments and/or device/equipment including: motor status contacts, valve position switches, pump start/stop commands, etc.
2. There are two different tagging standards for physical I/O points, depending on whether they are instruments or signals coming from or going to equipment/devices other than instruments.

3. Instrument tags follow the ISA standards and are somewhat different from the other physical I/O points, i.e. equipment and devices, in that those tags include not only an equipment code, like the instruments, but it also includes a Function Descriptor Code that is up to four characters long. Since a piece of equipment/device may have multiple I/O points connected to it (such as a motor starter) the Function Descriptor Code ensures uniqueness and clarifies the function performed by the specific I/O.
4. Software TagNames assigned to a PLC/RTU program are identical to the physical I/O points, i.e. Instrument Tags and Equipment/Device Tags.
5. Software TagNames that are generated by a controller or a host computer that are not tied directly to a physical I/O point, follow the same convention as the equipment and instrument tags, except a suffix is added to the end of the physical tag to indicate the origination/destination of that software tag, i.e. whether the point is logically created in the PLC/RTU or Host program and where it is sending its information to.

B. Lifted and updated from SAR SIDG.

1. Host SCADA Configuration Information – the fields in this section relate to configuration of alarming and general point information for use in the PMCS SCADA Host database.
 - a. HOST NODE NAME(S) - The computer name of PMCS SCADA Servers which will be polling the PLC, including OIUs.
 - b. HOST TAGNAME - The tagname used in the PMCS host software to reference the input point.
 - c. DB TYPE - The database point type used in the OIU and PMCS database definition for the point. See Table 4-3 in the System Integration Design Guide for a list of available database point types.
 - d. HOST DESCRIPTION - A description of the signal. The description field is limited to 40 characters.
 - e. ACTIVE STATE (1) - The definition of the energized state for a discrete point.
 - f. INACTIVE STATE (0) - The definition of the de-energized state for a discrete point.
 - g. ALARM STATE – Defines if either the Active or Inactive states will be used to generate an alarm a discrete point.
 - h. LOLO ALARM - The setpoint for the low low alarm limit for an analog point.
 - i. LO ALARM - The setpoint for the low alarm limit for an analog point.
 - j. HI ALARM - The setpoint for the high alarm limit for an analog point.
 - k. HIHI ALARM - The setpoint for the high high alarm limit for an analog point.
 - l. ALARM PRIORITY - The alarm priority. The alarm priority shall be defined as L, M, or H for low priority alarm, medium priority alarm, or high priority alarm, respectively. If the point does not require alarming, then this field shall be blank for the point. If multiple analog alarm setpoints are defined, alarm priorities shall be indicated for each alarm type.
2. PLC Host Read/Write Area – the fields in this section define the interface between the host database and the PLC/RTU.
 - a. HOST I/O ADDR - The register address in the PLC which the host will read to get the current value of the point.
 - b. HOST BIT NO - The bit within the register address in the PLC which the host will read to get the current value of the point.

- c. HOST PLC DATA TYPE - The data type of the signal in the PLC register. This defines how the PMCS interprets the data in the PLC register(s). Options for this field are based on the data types used in the PLC/RTU.
 - d. PLC SOFTWARE TAGNAME - The name of the register(s) that the PMCS host will read to current value of the point, as defined in the PLC/RTU software.
 3. PLC Intermediate Area – the fields in this section identify any intermediate registers used in the PLC/RTU to perform calculations or process the input signals from the I/O module.
 - a. INT I/O ADDR - The register address in the PLC where the intermediate data value is stored.
 - b. INT BIT NO - The bit within the register address in the PLC where the intermediate data value is stored.
 - c. INT DATA TYPE - The data type of the signal in the intermediate PLC register. Options for this field are based on the data types used in the PLC/RTU.
 - d. PLC SOFTWARE TAGNAME - The name of the register(s) in the PLC where the intermediate data value is stored, as defined in the PLC/RTU software.
 4. Field Interface Area – the fields in this section identify information about the field devices and register locations written to by the I/O modules.
 - a. PEER DEVICE – Indicates whether or not the point is transmitted from another PLC, as opposed to being acquired from local I/O.
 - b. FIELD DEVICE TAG - The name of the end device, in accordance with the INFOR (maintenance management system) naming convention and tagged in the field and/or on the contract drawings. This field is used as a cross-reference to the Field I/O List table.
 - c. POINT TYPE - The point type indicates AI, AO, DI, or DO for analog input, analog output, discrete input, or discrete output, respectively.
 - d. FIELD I/O ADDR. - The software register address where the I/O module places the data for the point. This field is used as a cross-reference to the Field I/O List table.
 - e. FIELD BIT NO. - The bit within the register address where the I/O module places the data for the point, as required. This field is used as a cross-reference to the Field I/O List table.
 5. Other fields
 - a. PLC/RTU EQUIPMENT TAG - The name of the PLC or RTU device, in accordance with the INFOR (maintenance management system) naming convention and tagged in the field and/or on the contract drawings. This field is used as a cross-reference to the Field I/O List table.
 - b. NOTES – Miscellaneous notes specific to the database point.

1.03 PEER TO PEER DATA COMMUNICATIONS DESCRIPTIONS NOTES

A. General

1. The Peer to Peer Data Communications list is intended to only show data (inputs or outputs) that is shared between two peer devices such as PLC/RTU controllers. The list does not include any other physical I/O points connected to the associated PLC/RTU or data points that are transmitted to or received from a Host computer.
2. For physical I/O points connected to a specific PLC/RTU, refer to the Field Input/Output (I/O) list.

3. For data points that are associated with a particular PLC/RTU that are transmitted to or received from a Host computer, please refer to the HostPack list.
4. PLC SOFTWARE TAGNAME - The name of the register(s) that the PMCS host will read to current value of the point, as defined in the PLC/RTU software.
5. DESCRIPTION - A description of the signal. The description field is limited to 40 characters.
6. HOST PLC DATA TYPE - The data type of the signal in the PLC register. This defines how the PMCS interprets the data in the PLC register(s). Options for this field are based on the data types used in the PLC/RTU.
7. ORIGINATION EQUIPMENT TAG - The name of the PLC or RTU device where the point data is coming from (source of the data), in accordance with the INFOR (maintenance management system) naming convention and tagged in the field and/or on the contract drawings. This field is used as a cross-reference to the Field I/O List table, Host Pack table, or other Peer to Peer tables.
8. ORIGINATION I/O ADDR - The register address in the source PLC which the destination peer device will read to get the current value of the point. This field is used as a cross-reference to the Field I/O List table, Host Pack table, or other Peer to Peer tables.
9. ORIG BIT NO - The bit within the register address in the source PLC which the destination peer device will read to get the current value of the point. This field is used as a cross-reference to the Field I/O List table, Host Pack table, or other Peer to Peer tables.
10. DESTINATION EQUIPMENT TAG - The name of the PLC or RTU device where the point data is being written to (consumer of the data), in accordance with the INFOR (maintenance management system) naming convention and tagged in the field and/or on the contract drawings. This field is used as a cross-reference to the Field I/O List table, Host Pack table, or other Peer to Peer tables.
11. DESTINATION I/O ADDR - The register address in the consumer PLC which the source peer device will write to provide the current value of the point. This field is used as a cross-reference to the Field I/O List table, Host Pack table, or other Peer to Peer tables.
12. DEST BIT NO - The bit within the register address in the consumer PLC which the source peer device will write to provide the current value of the point. This field is used as a cross-reference to the Field I/O List table, Host Pack table, or other Peer to Peer tables.
13. HOST INTERFACE? – Indicates whether the destination device passes the data to the PMCS host, or whether the data will be passed along to another peer device.
14. BLOCK MOVE TYPE – Indicates the function block or other method used to facilitate the transfer of peer data.
15. BLOCK MOVE DEVICE – The name of the PLC/RTU whose program includes the block move command. The Origination device can write the data to the Destination device, or the Destination device could read the data from the Origination device.

16. NETWORK PROTOCOL – The protocol used to transport the peer data.
17. NOTES – Miscellaneous notes specific to the database point.

SECTION 13390
APPENDIX C – AWU SOFTWARE TAGGING CRITERIA

For signals associated with a stand-alone instrument:

PPPPPP_TTTTTT_III_QQ

Where,

- PPPPPP = Process Identifier (abbreviation for process fluid shown on P&IDs)
- TTTTTT = Function Descriptor (see Austin_WDCS_LSTS_Software_Tag_Function_Descriptor_Standards_11122013.PDF)
- IIII = Unique Identifier (Loop numbers for instrument - limited to 4 characters)
- QQ = Qualifier (see AWU Tag Naming Qualifiers from SAR – Updated.PDF)

For signals associated with a piece of equipment:

PPPPPP_TTTTTT_III_QQ

Where,

- PPPPPP = Equipment Code (as will be entered in INFOR)
- TTTTTT = Function Descriptor (see Austin_WDCS_LSTS_Software_Tag_Function_Descriptor_Standards_11122013.PDF)
- IIII = Unique Identifier (Equipment ID - limited to 4 characters)
- QQ = Qualifier (see AWU Tag Naming Qualifiers from SAR – Updated.PDF).

END OF APPENDIX C

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SECTION 14130
TRAILER MOUNTED VALVE OPERATOR

PART 1 GENERAL

1.01 SUMMARY

- A. Furnish one complete trailer mounted valve operator assembly and accessories for operating valves as specified herein.

1.02 RELATED REQUIREMENTS

- A. Related work specified in this or other Sections.

1.03 SYSTEM DESCRIPTION

- A. Provide the trailer mounted valve operator as a complete unit, including the following items:
 - 1. One automatic valve operator with data logger.
 - 2. One 15 H.P. engine and hydraulic pump for valve operator operation.
 - 3. One trailer installation kit for mounting and setup.
 - 4. One handheld hydraulic valve exerciser
 - 5. One telescopic valve key.

1.04 SUBMITTALS

- A. Furnish in accordance with Specifications Section 01300, "Submittals" and Section 01730, "Operation and Maintenance Data".
 - 1. Shop Drawings. In addition to the items specified in Section 01300, "Submittals", furnish the following:
 - a. Product literature.
 - b. Sufficient detail to confirm construction features and materials of construction.
 - 2. Storage and handling instructions.
 - 3. Operation and maintenance instructions.

1.05 QUALITY ASSURANCE

- A. System Responsibility: Contract Documents describe details of complete equipment installation for purpose specified. CONTRACTOR is responsible for all details necessary to properly install, adjust, and place in operation a working system.

PART 2 PRODUCTS

2.01 MANUFACTURER(S)

A. Subject to compliance with the requirements of this Section, the following manufacturers and products are acceptable under this Section:

1. E. H. Wachs Company;
2. Or Owner approved equal.

2.02 MATERIALS AND/OR EQUIPMENT

A. Valve Exercising Equipment:

1. Provide a complete trailer mounted valve exercising equipment assembly including the automated valve operator, software and handheld controller.
2. Must be capable of operating valve in automatic exercise mode with “No assumption of valve size or direction”. Control must be portable and allow operator to stand at least 5 feet from the machine during operation. Controller must operate at least amount of torque possible in exercise mode to avoid valve damage. Controller must automatically stop machine rotation and reverse direction for 1-3 turns before allowing torque increase. Controller must allow operator to enter a torque limit. Controller must stop machine rotation when torque limit is reached.
3. Machine must accept 100% of reaction torque and permit hands free operation.
4. Torque operating range to be 0-750 ft. /lbs. torque.
5. Provides customizable data entry screens for valve data and valve activity data, including torque charts. Data transfer includes valve ID, operator ID, date and time of operation, torque, turns, and custom remarks. Provide software enabled microprocessor control of the valve exercising equipment to AWWA standards, full data logging and synchronization between the handheld and desktop computers. Supports GPS receivers using compact flash, serial cable, or Bluetooth.
6. Software to allow importing of existing data labels and categories with user defined fields.
7. Valve operating machine capable of 270 degree movement and 13’ of extendable reach from pedestal mount. No operator support or interaction required during valve exercise. All torque is transmitted back through machine only.
8. Dual hydraulic locking disc brakes to stabilize arm while positioning and in operation. Hydraulic brake pressure is controlled electronically. A check valve maintains brake pressure while holding torque. A sealed push-button disengages the check valve to release brakes. No pins to absorb torque reaction will be accepted.
9. Valve exerciser arm constructed of the following: Pivot arms- A500 steel structural square tube, 2 ½” x .120 wall (11 GA). Extension arm- A500 steel structural square tube, 2” x .120 wall (11 GA).
10. Automatic valve operator to be powder-coated 2 part urethane white.

11. Furnish one 2" telescopic valve key manufactured from high-strength steel, rated to 800 lb-ft of torque for use with ERV-750 and P/2 valve operator. Provide 1" square high strength cold rolled steel adaptor with swivel joint for misalignment. Telescoping valve key standard for 4'- 9' operation. Provide 36" extension key attachment.
 12. Handheld controller:
 - a. Handheld receiver to be used for and compatible with operation of the trailer mounted automatic valve operator.
 - b. GPS unit accuracy to be sub-meter.
 13. Manufacturer:
 - a. Automatic valve operator to be E. H. Wachs Company, ERV-750, or approved equal.
 - b. Controller to be a ruggedized HC-100 with GPS controller/datalogger, equipped with Pathfinder Pro 6T.
- B. Power Pack:
1. Power pack to include the engine, controls and hydraulic system.
 2. Engine to be a 15 horsepower gasoline engine.
 3. Controls to include the digital tachometer, engine hour meter, volt meter, arrow board control and service light switch.
 4. Hydraulic system to include a direct coupled pump rated at 8 gpm at 1,800 psi continuous duty, 10 gallon hydraulic reservoir with thermostatic controlled fan cooled heat exchanger. Instrumentation to include an oil level gauge, temperature gauge, pressure gauge and selected valve switching to a HTMA class II auxiliary hydraulic circuit.
 5. Manufacturer:
 - a. Kohler, model CH15S Command Pro15, or
 - b. approved equal.
- C. Trailer:
1. Trailer frame to be 2,300 lbs GVWR trailer with single axle, independent torsion wheel suspension. Uni-frame design converts from fork truck skid to trailer with bolt on components. All steel construction with metal deck. Tongue eight to be 200 lbs dry.
 2. Lighting to be TxDOT approved LED lighting with Weather Pack environmentally sealed connectors.
 3. Entire trailer is to be solvent washed and phosphoric etched. All seams are caulked then two part urethane paint applied. A durable plastic bed lining product to be applied to trailer deck. Fenders are powder coated for durable, chip resistant finish.
 4. Pintle with safety chains.
- D. Hydraulic Hand Held Wrench:
1. Hydraulic handheld wrench to have the following characteristics:

2. Hydraulic: 6-8 gpm (1500 psi to 1800 psi)
3. Capable of operating all gate valves 6-in to 60-in plus other equipment requiring mechanized turning.
4. Drive to be sealed light weight aluminum gear box with two-stage gear reduction, planetary primary with bronze/steel secondary (120/1 reduction).
5. Peak torque to be 800 ft/lbs.
6. Controls to include forward / reverse switch and dead man on/off.
7. Revolution counter to include built in “easy view” LCD counter with push button reset counts in 1/10 revolution, forward and reverse automatically.
8. Weight to not exceed 32 lbs.
9. Manufacturer:
 - a. E.H.Wachs Hydraulic POW-R-DRIVE 2 HT, item no 11-000-04 or,
 - b. Approved equal

E. Hydraulic Trash Pump:

1. Minimum capacity to be 800 gpm.
2. Pressure to be 2000 psi.
3. Flow range to be 7-10 gpm.
4. Maximum flow range to be 10 gpm (minimum).
5. Porting to be #10 SEAE (pressure); #12 SAE (return).
6. Connection to be ½ in. male pipe (pressure) and ½ in. male pipe (return).
7. Inlet diameter to be 4 in.
8. Discharge diameter to be 4 in. camlock.
9. Accessories to include lay-flat discharge hose, 4 in. x 25 ft with camlock fittings.
10. Manufacturer:
 - a. E.H.Wachs WTP4800, item no 08-000-04 or,
 - b. Approved equal

F. Accessories:

1. Heavy duty, expanded metal storage tray.
2. Programmable arrow board including eight function control box with six individual segments and (2) mounted halogen swiveling work lights.

3. A 50 foot spring rewind hose reel for auxiliary hydraulic power with quick disconnects.
4. Five (5) 36” key extensions to allow the telescoping key to reach all valves.

PART 3 EXECUTION

3.01 TRAINING OF OWNER’S PERSONNEL

- A. Manufacturer’s authorized representative shall provide training to OWNER designated personnel on the proper care, operation, and maintenance of the equipment specified herein. Manufacturer to provide a minimum of eight (8) hours of training services to the OWNER.

3.02 MEASUREMENT AND PAYMENT

- A. No separate measurement or payment for work performed under this Section. Include cost of same in Contract price bid for work of which this is a component part.

END OF SECTION

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SECTION 15050
PROCESS MECHANICAL PIPING - GENERAL REQUIREMENTS

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. This Section specifies the basic administrative and testing requirements for piping. Specific piping materials, systems and related installation and testing requirements are specified in other Sections of Division 15.

1.02 RELATED WORK

- A. Testing of Pipelines is specified in Section 01666.
- B. Piping materials and systems are included in other Sections of Division 15.
- C. Valves are included in Section 15100.
- D. Pipe insulation is included in Section 15250.

1.03 SUBMITTALS

- A. Submit, in accordance with Section 01300, general submittals for piping and piping systems are listed below. It is not intended that all submittals listed below be provided for all piping materials and systems. Refer to individual System or Piping Sections for specific submittals.
- B. Shop Drawings and Product Data
 - 1. Piping layouts in full detail.
 - 2. Location of pipe hangers and supports.
 - 3. Location and type of backup block or device to prevent joint separation.
 - 4. Large scale details of wall penetrations and fabricated fittings.
 - 5. Schedules of all pipe, fittings, special castings, couplings, expansion joints and other appurtenances.
 - 6. Catalog cuts of joints, couplings, harnesses, expansion joints, gaskets, fasteners and other accessories.
 - 7. Brochures and technical data on coatings and linings and proposed method for application and repair.
- C. Samples
- D. Design Data
- E. Test Reports
 - 1. Four copies of certified shop tests showing compliance with appropriate standard.

2. Four copies of all field test reports, signed by Contractor.

F. Certificates

1. Copies of certification for all welders performing work in accordance with ANSI B31.1.

G. Manufacturer's Installation (or application) instructions.

H. Statement of Qualifications

I. Manufacturers Field Report

J. Project Record Document

K. Operation and Maintenance Data in accordance with Section 01730.

L. Warranties

1.04 REFERENCE STANDARDS

A. ASTM International

1. ASTM A307 - Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength

B. American National Standards Institute (ANSI)

1. ANSI B16.5 - Pipe Flanges and Flanged Fittings

2. ANSI B31.1 - Power Piping

C. American Welding Society (AWS)

1. AWS B2.1 - Specification for Welding Procedure and Performance Qualifications

D. American Water Works Association (AWWA)

1. AWWA Manual M11 - Steel Pipe - A Guide for Design and Installation

E. American Society of Mechanical Engineers (ASME)

F. Underwriters Laboratories (UL)

G. Factory Mutual (FM)

H. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

A. All materials shall be new and unused.

B. Install piping to meet requirements of local codes.

- C. Provide manufacturer's certification that materials meet or exceed minimum requirements as specified. Reference to standards such as ASTM and ANSI shall apply to those versions in effect at the time of bid opening.
- D. Coordinate dimensions and drilling of flanges with flanges for valves, pumps and other equipment to be installed in piping systems. Bolt holes in flanges to straddle vertical centerline.
- E. Reject materials contaminated with gasoline, lubricating oil, liquid or gaseous fuel, aromatic compounds, paint solvent, paint thinner and acid solder.
- F. Pipe-joint compound, for pipe carrying flammable or toxic gas, must bear approval of UL or FM.
- G. Unless otherwise specified, pressures referred to in all Piping Sections are expressed in pounds per square in gauge above atmospheric pressure, psig and all temperature are expressed in degrees Fahrenheit (F).

1.06 DELIVERY, STORAGE AND HANDLING

- A. During loading, transportation and unloading take care to prevent damage to pipes and coating. Carefully load and unload each pipe under control at all times. Place skids or blocks under each pipe in the shop and securely wedge pipe during transportation to ensure no injury to pipe and lining.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Specific piping materials and appurtenances are specified in the respective Piping or System Sections.
- B. General installation materials shall be as specified below.
 - 1. Unions shall be brass or bronze unions for joining nonferrous pipe; malleable brass or bronze-seated iron or steel unions for joining ferrous pipe; PVC unions for joining PVC pipe; CPVC unions for joining CPVC pipe.
 - 2. Flanged Joints. Bolt and nuts, Grade B, ASTM A307, Type 304 stainless steel, bolt number and size same as flange standard; studs - same quality as machine bolts; 1/16-in thick rubber gaskets with cloth insertions; rust-resistant coatings.
 - 3. Temporary Plugs shall be standard plugs or caps which are suitable for permanent service.
 - 4. Wall Sleeve Seals shall be as specified in Paragraph 3.05.
 - 5. Flexible Connections shall be flanged spool type, 180 degree F maximum service, single filled arch with synthetic rubber tube and cover, steel-ring reinforced synthetic fiber carcass, with flanges drilled to 150 lb ANSI B16.5. Steel retaining rings, control rods and compression sleeves shall be provided where shown and as required for the working pressure of the system in which the joint is installed. All flexible joints shall be rated for the working pressure of the system in which they are installed.

PART 3 EXECUTION

3.01 GENERAL

- A. All dirt, scale, weld splatter, water and other foreign matter shall be removed from the inside and outside of all pipe and sub-assemblies prior to installing.
- B. All pipe joints and connections to equipment shall be made in such a manner as to produce a minimum of strain at the joint.
- C. Install piping in a neat manner with lines straight and parallel or at right angles to walls or column lines and with risers plumb. Run piping so as to avoid passing through ductwork or directly under electric light outlets and/or interference with other lines or extending beyond furring lines as determined by Architectural Drawings. All work shall be accomplished using recognized methods and procedures of pipe fabrication and in accordance with the latest revision of applicable ANSI Standards, ASME Codes and Pipe Fabrication Institute Standards.
 - 1. Use full length of pipe except where cut lengths are necessary. Do not spring or deform piping to make up joints.
 - 2. Pipe shall be cut square, not upset, undersize or out of round. Ends shall be carefully reamed and cleaned before being installed.
 - a. Bending of pipe is not permitted. Use fittings for all changes in direction.
 - 3. Do not use bushings except where specifically approved by Owner's Representative. Reducers shall be eccentric to provide for drainage from all liquid-bearing lines and facilitate air removal from water lines.
 - 4. Verify the locations and elevations of any existing piping and manholes before proceeding with work on any system. Any discrepancies between the information shown on the Drawings and the actual conditions found in the field shall be reported at once to the Engineer. No claim for extra payment will be considered if the above provision has not been complied with.
 - 5. Where lines of lower service rating tie into services or equipment of higher service rating the isolation valve between the two shall conform to the higher rating.
 - 6. Mitering of pipe to form elbow is not permitted.
 - 7. All piping interiors shall be thoroughly cleaned after installation and kept clean by approved temporary closures on all openings until the system is put in service. Closures should be suitable to withstand the hydrostatic test.
- D. Test Connections
 - 1. Provide 1/2-in female NPT test connection equipped with 1/2-in brass plug on all pump suction and discharge lines. Where indicated on the Drawings, test connections should be equipped with bar stock valve and gauge. Provide test connections at all steam traps. The connection shall be located on the discharge side of the trap between the trap and the first valve. It shall consist of a 1/2-in branch connection terminated with a gate valve.
- E. Unions

1. Unions screwed or flanged shall be provided where indicated and in the following locations even if not indicated.
 - a. In long runs of piping to permit convenient disassembly for alterations or repairs.
 - b. In by-passes around equipment.
 - c. In connections to tanks, pumps and other equipment between the shut-off valve and the equipment.
 - d. In connections on both sides of traps, controls and automatic control valves.
2. Use unions to allow dismantling of pipe, valves and equipment.

F. Vents and Drains

1. Provide vents and drains in the following places:
 - a. Water Lines - Vents at high points and drains at low points.
 - b. Air Lines - Drains at low points.

3.02 WELDING

- A. Welding in accordance with ANSI B31 and AWS B3.0.
- B. Install welding fittings on all welded lines. Make changes in direction and intersection of lines with welding fittings. Do not miter pipes to form elbows or notching of straight runs to form tees, or any similar construction. Do not employ welder who has not been fully qualified in above specified procedure and so certified by approved welding bureau or similar locally recognized testing authority.

3.03 FLANGED JOINTS

- A. Make flanged joints with bolts; bolt studs with nut on each end; or studs with nuts where one flange is tapped. Use number and size of bolts conforming to same ANSI Standard as flanges. Before flanges pieces are assembled, remove rust resistant coating from machined surfaces, clean gaskets and smooth all burrs and other defects. Make up flanged joints tight, care being taken to prevent undue strain upon valves or other pieces of equipment.

3.04 SLEEVE COUPLINGS

- A. Install tierods, pipe clamps or bridles when sleeve type couplings or fittings are used in piping system where indicated, and at changes in direction or other places as necessary, to prevent joints from pulling apart under pressure. Use bridles and tierods at least 3/4-in in diameter, except where tierods replace flange bolts of smaller size, in which case fit with nut on each side of pair of flanges. Joint harnessing shall conform, as a minimum, to the requirements for the bolts and tie bolt lugs as set forth in AWWA Manual M11.

3.05 WALL SLEEVE SEALS

- A. Use expandable rubber segmented sealing device with corrosion-resistant fasteners to make watertight the annular space between pipe and sleeve. Determine the required inside diameter of each individual wall opening or sleeve to fit the pipe and seal it to assure a watertight joint as recommended by the manufacturer, before ordering, fabricating or installing. Install pipe concentrically through wall sleeve. Install and tighten seal per manufacturer's instructions.

3.06 TESTING

- A. Test all pipelines for water/gas tightness as specified in the Piping or System sections. Furnish all labor, testing plugs or caps, pressure pumps, pipe connections, gauges and all other equipment required. Testing shall be performed in accordance with one or more of the testing procedures appended to this Section as specified in each Piping or System Section. All testing shall be performed in the presence of the Owner's Representative.
- B. Repair faulty joints or remove defective pipe and fittings and replace as approved by the Engineer. Retest.

3.07 DISINFECTION

- A. After satisfactory testing, all potable distributed systems shall be thoroughly disinfected with a solution of not less than 50 parts per million of available chlorine. The disinfecting solution shall be allowed to remain in the system for a period of 3 hours after which time all valves and faucets shall be opened and the system shall be flushed with clean water.
- B. Water being flushed from structures or pipelines after disinfection with a chlorine residue of 2 mg/l or greater, shall be treated with a dechlorination solution, in a method approved by the Engineer, prior to discharge.
- C. Flushing
 - 1. Lines tested with water shall be completely drained.
 - 2. Lines shall be flushed, after test.
- D. Test Records
 - 1. Records shall be maintained of all tests performed.
 - 2. Test records shall include:
 - a. Date of Testing
 - b. Identification of Piping Tested
 - c. Test Fluid
 - d. Test Pressure
 - e. Signatures of Contractor and Owner's Representative
 - 3. If leaks are found, they shall be noted, on the record. After correction, retesting as specified for original test.
 - 4. Records of test shall be maintained by the Contractor and furnished to the Engineer.

END OF SECTION

SECTION 15053
COMMON WORK RESULTS FOR HVAC

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes the following:

1. Piping materials and installation instructions common to most piping systems.
2. Dielectric fittings.
3. Mechanical sleeve seals.
4. Sleeves.
5. Escutcheons.
6. Grout.
7. HVAC demolition.
8. Equipment installation requirements common to equipment sections.
9. Supports and anchorages.

1.02 DEFINITIONS

- A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.
- B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
- C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
- D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings, closets, and chases.

1.03 SUBMITTALS

- A. Welding certificates.

1.04 QUALITY ASSURANCE

- A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

- B. Electrical Characteristics for HVAC Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.
- C. All HVAC work shall comply with the requirements of applicable portions of Division 16 and all local and national electric codes, unless specified otherwise in this section.

PART 2 PRODUCTS

2.01 PIPE, TUBE, AND FITTINGS

- A. Refer to individual piping Sections for pipe, tube, and fitting materials and joining methods.
- B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.02 JOINING MATERIALS

- A. Refer to individual Division 15 piping Sections for special joining materials not listed below.
- B. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.
- C. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
- D. Brazing Filler Metals: AWS A5.8, BCuP Series or BAg1, unless otherwise indicated.
- E. Welding Filler Metals: Comply with AWS D10.12.

2.03 DIELECTRIC FITTINGS

- A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.
- B. Insulating Material: Suitable for system fluid, pressure, and temperature.
- C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180 deg F.
- D. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.
- E. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 deg F.

2.04 SLEEVES

- A. Galvanized-Steel Sheet: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

- B. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.
- C. PVC Pipe: ASTM D 1785, Schedule 40.

2.05 ESCUTCHEONS

- A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.
- B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.
- C. One-Piece, Cast-Brass Type: With set screw.
 - 1. Finish: Polished chrome-plated.
- D. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.
 - 1. Finish: Polished chrome-plated.

2.06 GROUT

- A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
 - 1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
 - 2. Design Mix: 5000-psi, 28-day compressive strength.
 - 3. Packaging: Premixed and factory packaged.

PART 3 EXECUTION

3.01 HVAC DEMOLITION

- A. Refer to Division 1 Section 01505 "Construction and Demolition Waste Management" for general demolition requirements and procedures.
- B. Disconnect, demolish, and remove HVAC systems, equipment, and components indicated to be removed.
 - 1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
 - 2. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.
 - 3. Equipment to Be Removed: Disconnect and cap services and remove equipment.

4. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.
- C. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

3.02 PIPING SYSTEMS - COMMON REQUIREMENTS

- A. Install piping according to the following requirements and Division 15 Sections specifying piping systems.
- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
- D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- F. Install piping to permit valve servicing.
- G. Install piping at indicated slopes.
- H. Install piping free of sags and bends.
- I. Install fittings for changes in direction and branch connections.
- J. Install piping to allow application of insulation.
- K. Select system components with pressure rating equal to or greater than system operating pressure.
- L. Install escutcheons for penetrations of walls, ceilings, and floors.
- M. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.
- N. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
 1. Install steel pipe for sleeves smaller than 6 inches in diameter.

- O. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials.
- P. Verify final equipment locations for roughing-in.
- Q. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.03 PIPING JOINT CONSTRUCTION

- A. Join pipe and fittings according to the following requirements and Division 15 Sections specifying piping systems.
- B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
- E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

3.04 PIPING CONNECTIONS

- A. Make connections according to the following, unless otherwise indicated:
 - 1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.

3.05 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

- A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.
- B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
- C. Install HVAC equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.
- D. Install equipment to allow right of way for piping installed at required slope.

3.06 ERECTION OF METAL SUPPORTS AND ANCHORAGES

- A. Refer to Division 5 Section "Metal Fabrications" for structural steel.

- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor HVAC materials and equipment.
- C. Field Welding: Comply with AWS D1.1.

3.07 GROUTING

- A. Mix and install grout for HVAC equipment base bearing surfaces, pump and other equipment base plates, and anchors.
- B. Clean surfaces that will come into contact with grout.
- C. Provide forms as required for placement of grout.
- D. Avoid air entrapment during placement of grout.
- E. Place grout, completely filling equipment bases.
- F. Place grout on concrete bases and provide smooth bearing surface for equipment.
- G. Place grout around anchors.
- H. Cure placed grout.

END OF SECTION 15053

SECTION 15061
STEEL PIPE AND FITTINGS

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. Furnish all labor, materials, equipment and incidentals required and install all non-buried steel pipe and appurtenances as shown on the Drawings and as specified herein.
- B. Steel pipe shall include black steel and galvanized steel pipe with fittings, flanges, and unions, complete with coatings, wrappings, linings, and painting.

1.02 RELATED WORK

- A. Concrete work is specified in Division Series 400.
- B. Buried pipe is included in Division 2.
- C. Field Painting, except as specified herein, is included in Section 09902.
- D. Piping – General Requirements is included in Section 15050.
- E. Valves and Appurtenances are included in Section 15100.
- F. Split couplings, sleeve couplings, and joint harnessing are included in Section 15120.
- G. Pipe hangers and supports are included in Section 15140.
- H. Pipe insulation is included in Section 15250.

1.03 SUBMITTALS

- A. Submit, in accordance with Section 01300, working drawings, shop drawings, and material specifications including the following:
 - 1. A list of materials to be furnished, the names of the suppliers, and the date of delivery of materials to the site.
 - 2. Complete shop drawings of all components detailing materials, conformance to standards, dimensions, and design pressure ratings.
 - 3. Fully dimensioned layout and cross section drawings of pipelines locating jointing, fittings, couplings, sleeves, expansion joints, supports, anchors, harnessing, valves, and equipment. Pipe size, type, and materials shall be labeled on the drawing.
 - 4. Complete schedule of all components included in the pipeline drawings, indicating the material and schedule number of thickness of all pipe, the materials and class of all fittings and valves.
 - 5. Details of pipe coating, wrapping, lining, and painting.
 - 6. Certification of pipe design to the criteria specified herein.

7. Certification of qualifications of all welders to perform shop and field welding of piping.

1.04 REFERENCE STANDARDS

A. National Sanitation Foundation (NSF)

1. 61 – Drinking Water System Components – Health Effects

B. ASTM International

1. ASTM A47 - Ferritic Malleable Iron Castings.
2. ASTM A53 - Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
3. ASTM A105 - Carbon Steel Forgings, for Piping Applications.
4. ASTM A126 – Gray Iron Casting for Valves, Flanges, and Pipe Fittings
5. ASTM A139 – Electric-Fusion (ARC)-Welded Steel Pipe
6. ASTM A153 - Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
7. ASTM A193/A193M – Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service.
8. ASTM A234 - Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.
9. ASTM A283/A283M – Low and Intermediate Tensile Strength Carbon Steel Plates, Shapes and Bars
10. ASTM A307 - Carbon Steel Bolts and Studs 60,000 psi Tensile Strength.
11. ASTM A714 - Standard Specification for High-Strength Low-Alloy Welded and Seamless Steel Pipe.

C. ANSI/ASME

1. ANSI/ASME B1.1 – Unified Inch Screw Threads (UN and UNR Thread Form)
2. ANSI/SAME B16.1 - Cast Iron Pipe Flanges and Flanged Fittings
3. ANSI/ASME B16.3 – Malleable-Iron Screwed Fittings, 125 and 150 lb
4. ANSI/ASME B16.4 – Cast Iron Threaded Fittings
5. ANSI/ASME B16.5 - Pipe Flanges and Flanged Fittings
6. ANSI/ASME B16.9 - Factory-Made Wrought Steel Buttwelding Fittings
7. ANSI/ASME B16.11 – Forged Steel Fittings, Socket-Welding and Threaded
8. ANSI/ASME B16.21 – Non-Metallic Gaskets and Pipe Flanges

9. ANSI/ASME B18.2.1 – Square and Hex Bolts and Screws
10. ANSI/ASME B31.1 – Power Piping
11. ANSI/ASME B36.10M – Welded and Seamless Wrought Steel Pipe

D. American Water Works Association (AWWA)

1. ANSI/AWWA C200 – Steel Water Pipe 6 Inches and Larger
2. ANSI/AWWA C203 – Coal-Tar Protective Coatings and Linings for Steel Water Pipelines – Enamel and Tape – Hot-Applied
3. ANSI/AWWA C205 – Cement-Mortar Protective Lining and Coating for Steel Water Pipe – 4 Inch and Larger – Shop Applied
4. ANSI/AWWA C206 – Field Welding of Steel Water Pipe
5. ANSI/AWWA C207 – Steel Pipe Flanges for Waterworks Service – Size 4 Inch through 144 Inch
6. ANSI/AWWA C208 – Dimensions for Fabricated Steel Water Piping Fittings
7. ANSI/AWWA C210 – Liquid Epoxy Coating Systems for Interior and Exterior of Steel Water Pipelines
8. ANSI/AWWA C214 – Tape Coating Systems for the Exterior of Steel Water Pipelines
9. ANSI/AWWA C602 - Cement-Mortar Lining of Water Pipelines - 4 In. (100 mm) and Larger - in Place
10. ANSI/AWWA C651 - Disinfecting Water Mains
11. AWWA M11 – Steel Pipe – A Guide for Design and Installation

E. American Welding Society (AWS)

- F. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

- A. All steel pipe and fittings shall be furnished by manufacturers who are fully experienced, reputable and qualified in the manufacture of the items to be furnished. The equipment shall be designed, constructed and installed in accordance with the applicable standards of ASTM, ANSI and AWWA as specified herein.
- B. Utilize only certified welders, having current certificates conforming to the requirements of the ASME code to perform all welding on steel pipes. Welders shall be qualified under the requirements of Section IX Welding Qualifications, of the ASME Boiler and Pressure Vessel Code.

- C. The manufacturer's name or trademark, the year of manufacture, and the specification to which the pipe is manufactured shall be rolled, permanently inscribed, or stenciled on the pipe surface at the manufacturer's plant. Pipe 1-1/2 inches and less in nominal diameter shall be bundled and tagged.
- D. The Engineer reserves the right to perform shop inspections of the manufacture of the pipe. Provide at least 30 days' notice to the Engineer prior to the beginning of any work so that inspection may be arranged. Furnish all facilities required for the inspection of materials and workmanship in the shop. Inspectors shall be allowed free access to the necessary parts of the facility for inspections.
 - 1. Inspection may include, but not be limited to, welding inspection, review of certified material test reports, traceability check, and witness of assembly and fit-up. Prior to manufacture, the pipe fabricator shall supply the following information on suppliers of plate, piping, and other components: Items(s) furnished, company name and address, contact name, telephone and fax number. The Engineer reserves the right to visit any or all of the suppliers and conduct inspections at their facilities.
 - 2. The inspector shall have the authority to reject any material or work that does not meet the requirements of the Contract Documents.
 - 3. Inspection at the shop is intended as a means of facilitating the work and avoiding errors, but is expressly understood that it will in no way relieve the Contractor from the responsibility for furnishing proper materials or workmanship.
 - 4. The costs of all welding supervision and inspections and tests shall be borne by the Contractor. The Contractor shall engage inspectors to inspect welded connections and to perform tests and prepare test reports. Welds shall receive non-destructive testing as required by the specification under which the pipe is manufactured.
 - 5. Welds that are required to be corrected shall be corrected or redone and retested at the Contractor's expense and to the satisfaction of the Engineer and/or an acceptable independent testing lab.
 - 6. Submit certified materials test reports indicating physical and mechanical properties and heat treatment for all piping components.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Pipe, fittings, and appurtenances shall be delivered, stored, and handled in accordance with the provisions of Division 1, and as follows:
- B. When require for maintaining its circular shape and preventing distortion, each length of pipe shall be temporarily braced with an approved type of internal spider in each end of the pipe during handling and installation.
- C. Coated pipe shall be protected at all times and handled with equipment designed to prevent damage to the coatings and linings, such as stout wide canvas slings and wide padded skids. The use of bare chains, cables, hooks, metal bars or narrow skids in contact with the coating will not be permitted. Pipes shall be separated so that they do not bear against each other. During transit, pipes shall be securely fastened to their transport skid to prevent movement. Provide for prompt and efficient repair of all abrasions and injuries to pipe coatings and linings.

1.07 SYSTEM DESCRIPTION

- A. Steel piping shall be installed in the locations shown on the Drawings.
- B. The equipment and materials specified herein are intended to be standard types of steel pipe and fittings for use in transporting water, wastewater, residuals, air, and chemical solutions.
- C. Steel piping system listed below shall be designed for the following conditions:

| | |
|---------------------|----------------------------|
| System: | Non-potable Water |
| Material: | Galvanized Steel ASTM A-53 |
| Fluid: | Non-potable Water |
| Design Pressure: | 90 psi |
| Test Pressure: | Refer to Section 01666 |
| Temperature: | Ambient to 110 degrees F |
| Lining | Cement Mortar |
| Special Conditions: | Insulation |

PART 2 PRODUCTS

2.01 PIPE

- A. Steel pipe through 24 inch diameter shall conform to ASTM A-53. Where indicated on the Drawings to be galvanized, pipe shall be hot-dipped galvanized after fabrication.
- B. Steel pipe 30 inch diameter and larger shall conform to AWWA C200 and fabricated of plates meeting the requirements of ASTM A283/A283M, Grade C, or ASTM A139, Grade A, having a minimum yield strength of 30,000 psi, fusion welded in accordance with the Code for Pressure Piping, ASME B31.1, to develop full plate strength. Pipe shall conform to dimensions for steel pipe in accordance with ASME B36.10M. Pipe shall be fabricated with straight-seam welds or spiral-seam welds with smooth uniform cross section to provide pipe with a neat external appearance. Straight seam pipe shall have not more than two longitudinal butt welded seams. Girth seams shall be butt welded and shall not be closer than 6 feet apart except in specials and fittings. Spiral lap welded steel pipe is not allowed. Pipe shall be provided in lengths of approximately 20 feet.
- C. Steel pipe wall thickness shall be as specified in the applicable Standards or as determined by the supplier to meet the performance and pressure ratings specified herein in accordance with the provisions of AWWA Manual M11.
- D. Circumferential deflection of all pipe in-place shall not exceed 2.0 percent of the pipe diameter.
- E. NOTE: Tnemec Company Inc. currently manufactures two interior lining products or use in steel pipe. The first is Tnemec Series 22 or FC 22 Epoxoline that have been developed for use in potable water applications and are NSF 61 approved. The second is Tnemec Series 431 Perma-Shield PL. The Perma-Shield lining has been developed specifically for severe abrasion resistance and for raw water application. To date, CDM Smith does not have experience with the use of these products yet. Linings shall be applied in accordance with AWWA Standards. Linings for pipe shall be factory applied except for cut-backs as required for field welded pipe. Field welding of pipe shall be permitted only for pipe assemblies that can be field repaired and field re-coated following welding. Utilize flanged joints wherever linings cannot be accessed to perform thorough repair and recoating for welded pipelines.

1. Where specified herein, the interior of the pipe shall be coated with an NSF 61-approved epoxy lining, in accordance with AWWA C210. The lining shall be applied in two coats achieving a minimum dry film thickness of 16 mils. The epoxy-lining shall be TnemecSeries 22 or; FC-22 or equal.
 2. Where specified herein, the interior of the pipe shall be cement mortar lined in accordance with AWWA C205, shop applied. Field repair of cement mortar lining after field cutting or welding shall be in accordance with AWWA C602. Fabricated pipe and fittings shall be cement mortar lined after fabrication. Apply a seal coat of asphaltic material in conformance with AWWA C203 over the cement mortar lining. Seal coat for potable water piping shall be NSF61 approved.
- F. Tapped bosses for connection of small diameter pipes to main lines shall be welded-on Steel "Weld-O-Let" with tapped outlet and contoured mating surface to the pipe wall. Tapped bosses shall be shop fabricated with the pipe, and all coatings and linings of the pipe shall be repaired at the location of installation of the tapped boss.

2.02 STEEL PIPE FITTINGS

- A. Fittings shall be manufactured to standard dimensions, suitable for the pressures specified. Fittings shall be provided of the same or heavier wall thickness and/or pressure rating as the pipe of which they are a part. Strength, physical and chemical requirements shall meet or exceed the requirements specified for the pipe.
- B. Fittings for pipe 2 inches diameter and less shall be of the screwed pattern, except as shown or specified otherwise.
1. Screwed fittings 2 inches and smaller shall be malleable iron flat bank fittings, ASME B16.3, 125 pounds. For high pressure service, conform to ASME B16.3, 250 pounds. Malleable iron shall conform to the requirements of ASTM A197.
 2. Where shown or specified, screwed end fitting of cast iron, conforming to the requirements of ASME B16.4, 125 pound standards for general service and 250 pound for high pressure service shall be provided. Cast iron shall meet the requirements of ASTM A126.
 3. All threads shall be clean cut and smooth conforming to the American Standard for Pipe Threads, ASME B1.1.
 4. Unions shall be of malleable iron fitted with brass to iron seats.
 5. For galvanized pipe, fittings shall also be hot dipped galvanized and shall conform to ASTM A153.
- C. Socket Welding Fittings
1. Socket welding fittings shall be provided on pipe three inches and smaller, and shall meet the requirements of ASME B16.11 with steel conforming to ASTM A105/A105M, Grade 2. Fittings shall be rated 2000 pounds minimum.
 2. Socket welding fittings shall be welded in conformance with the applicable provisions of the Code for Pressure Piping, ASME B31.1.

D. Butt Welding Fittings

1. Butt welding fittings shall be provided on pipe greater than three inches diameter, and shall meet the requirements of ASME B16.9.
2. Where welding fittings are approved for assembly in cement lined pipelines, fittings shall be provided with a plain end, grooved end or shouldered end section welded on each end of the fitting and assembled with sleeve-type, groove type, or shoulder-end couplings as required. Long tangent welding fittings may be substituted for welded-on spool piece fittings provided that they can accommodate the flexible pipe couplings.

E. Flanged Fittings

1. Provide cast iron or steel flanged fittings where shown on the Drawings or specified herein.
2. Cast iron flanged fittings for general service shall conform to the requirements of ASME B16.1.
3. Steel flanged fittings shall utilize forged steel slip-on flanges. Fittings shall be Class 125 and Class 250 fittings conforming to the requirements of ASME B16.5, 150 pound or 300 pound, respectively as specified, except flanges that are plain faced shall be provided. Provide Class 125 fittings conforming to AWWA C207, Class B.
4. Cast steel flanged fittings shall be assembled with forged steel flanges of the same pressure rating, conforming to the requirements of ASME B16.5.

F. Fabricated Steel Fittings

1. Unless otherwise shown or specified, fittings 24 inches and larger shall be fabricated in accordance with the Code for Pressure Piping, ASME B31.1 and as specified herein.
2. The minimum radii of the centerlines of bends shall be 1.5 times the nominal pipe diameter unless specifically shown otherwise on the Drawings. The included angle between the point of tangency of the bend and connecting straight pipe shall include not less than the number of bend segments as follows:

| <u>Bend</u> | <u>Number of Full Segments</u> | <u>Number of Part Segments</u> |
|--------------|--------------------------------|--------------------------------|
| 75 – 90 deg. | 4 | 2 |
| 60 – 74 deg. | 3 | 2 |
| 45 – 59 deg. | 2 | 2 |
| 30 – 44 deg. | 1 | 2 |
| 0 – 29 deg. | 0 | 2 |

3. Full segments shall consist of sections with ends cut to form included angles of 15 degrees; part segments shall consist of section up to 7-1/2 degrees. In accordance with the above table, a 90 degree bend shall require four 15 degree segments, two 7-1/2 degree segments at the ends of the fitting and one additional 15 degree segment.
4. Fittings for cement line pipelines shall be lined after fabrication.

5. Fabricated fittings intended for installation with flexible pipe couplings shall be provided with extra-long end segments extending past the point of tangency of the radius to the segment centerline to accommodate the length of the coupling and any required joint restraint.
6. Reducers shall be provided with the same laying length as American Standard Class 125.
7. Fabricated fittings shall be reinforced in accordance with AWWA Manual M11.

2.03 JOINTS FOR STEEL PIPING

- A. Joints for steel piping two inches diameter and less shall be screwed joints with clean cut threads conforming to the American Standard for Pipe Threads, ASME B1.1. Screwed joints shall be made up with good quality thread compound, suitable for the intended service, applied to the make thread only.
- B. Joints for steel piping larger than two inches shall be welded with butt, socket, or slip-on welded flanges.
- C. Flanged joints for steel pipe shall be of the slip-on welding type with hubs meeting the requirements of ASME B16.5, or butt welded welding neck flanges meeting the requirements of ASME B16.5. Flanged joints for steel water pipe shall conform to AWWA C207. Slip-on flanges shall be welded to the steel pipe at the hub and at the pipe end in conformance with the Code for Pressure Piping, ASEM B31.1. Flanges shall be plain flat faced for connections to cast iron valves, fittings, and equipment. Raised face flanges shall be provided to connections to adjacent steel pipe and fittings.
 1. Blind flanges shall be in accordance with ASEM B16.5 plain faced.
 2. Where flanged connections are indicated or otherwise required on pipe 2-in or less for connection to flanged valves, fittings and appurtenances, they shall be made up using companion type flanges. Where flanged fittings are indicated or otherwise required, they shall be made up using threaded steel nipples and steel companion type flanges. Companion flanges shall be steel, 150 lb ANSI Standard flat face flanges of the threaded type. Flanges shall be spot faced on the back around each bolt hole. For galvanized pipe, flanges shall also be hot-dipped galvanized.
 3. Steel 150 pound welding flanges shall be used for assembly with Class 125 cast iron flanged fittings, valves, and equipment. Steel 300 pound flanges shall be used for assembly with Class 250 cast iron flanged fittings, valves, and equipment. AWWA Class B steel hub flanges shall be used for assembly with 25 pound cast iron flanged fittings.
 4. Flanged joints shall be made with bolts or bolt studs with a nut on each end. Stud bolts shall be used for all bolting sizes 1-3/4 inches and larger. Bolts, stud bolts, and nuts shall meet the requirements of ASTM A307 Grade B, except for high temperature service where alloy steel bolts, ASTM A193/A193M, Grade B5 shall be used. Bolts and stud bolts shall conform to the dimensional requirements of ASME B18.2.1 with rolled threads conforming to ASME B1.1, Coarse Series, Class 2 fit. Bolts and stud bolts and nuts shall be of American Standard heavy unfinished hexagonal type. Bolts shall be provided with a 1/4-inch projection beyond the nut when the joint with gasket is assembled.
 5. Flange gaskets shall be ring type gaskets for pipe larger than 12 inches diameter, and full face gaskets for pipe sizes 12 inches diameter and smaller. Gasket dimensions shall conform to the

requirements of ASME B16.21, unless specified otherwise. Gaskets shall be as thin as the finish and accuracy of the flange surface will permit.

- a. For general service, rubber gaskets shall be 1/8 inch thick and meet the requirements of AWWA C207
 - b. Gasket material shall be specifically recommended for the service by the gasket manufacturer and as approved by the Engineer.
6. Insulated flanged joints shall be provided as indicated on the Drawings. Flange insulation kits shall include flange insulating gasket, flange bolt insulating sleeves, and bolt insulating washers.

2.04 SURFACE PREPARATION AND SHOP PRIME PAINTING

- A. All piping and fittings exposed to view shall have its surface prepared and be shop primed as specified in Section 09901. Surface preparation and shop priming is a part of the work of this Section. Pipe finish painting and marking is included in Division 9, but it shall be part of the work of this Section to assist as required by the Engineer in identifying pipe contents, direction of flow and all else required for proper marking of pipe.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Steel pipe shall be installed true to alignment, and rigidly supported anchors shall be provided where required under Section 15140 or as shown on the Drawings. Where temporary supports are used during construction, provide sufficient strength and rigidity to prevent shifting or distortion of the pipe. After installation, the piping shall be tested as specified herein.
- B. When cutting of pipe is required, the cutting shall be done by machine in a neat workmanlike manner without damage to the pipe. Cut ends shall be smooth and at right angle to the axis of the pipe. All steel pipe shall be thoroughly cleaned before installation including smoothing and cleaning interior and exterior cut ends. All uncoated pipes shall be placed on end and hammered to remove scale and loose particles. Any damage to linings shall be repaired to the satisfaction of the Engineer before the pipe is installed.
- C. Welding of steel butt-welding fittings, steel fabricated fitting and steel pipe shall be in strict conformity with the Code for Pressure Piping, ASME B31.1, Section 6 and its Supplements. Certificates of qualifications of current issue, conforming to the requirements of the Code shall be submitted to the Engineer before proceeding with any pipe welding. Backing rings shall be used for all pipe welding butt joints unless otherwise specified. Backing rings shall be of carbon steel with spacer nubs that strike-off or melt with the weld.
- D. Field welding of cement mortar lined steel pipe shall be performed only where approved and in accordance with AWWA C206. Joints not approved for field welding shall be flanged or couplings as specified.
 1. The ends of the lined pipe for pipe-to-pipe joints shall be machine cut to provide an approximate bevel of 27-1/2 degrees. Ends may be chipped provided there is no damage to the cement lining. Ends shall be cleaned of scale, rust, oil and other foreign matter. Where fittings already having a bevel of 37-1/2 degrees are to be welded to pipe, pipe ends shall be beveled to a 17-1/2 degree angle, making a total angle of bevel between joints of approximately 55 degrees. A 1/8 inch land shall be provided where possible.

2. Pipe ends to be joined shall be approximately 1/32 inch apart before tacking. Backing rings shall not be used at welded joints in cement mortar lined pipe. Small tack welds shall be made using a 1/8 inch electrode. The first bead or layer of welding shall be laid by bridging across from bevel to bevel at the bottom of the groove just at the top of the land. A suitable crown reinforcement layer shall be made on the top of the joint to finish off.
 3. Direct current (DC) shall be used for welding, with the base material on the negative side.
 4. The first pass shall be a stringer bead using a 1/8 inch electrode with a current of 80 to 90 amperes at 50 to 55 Volts. The second and succeeding passes shall be woven beads using a 1/8 inch electrode and a current of 90 to 100 amperes at 55 to 58 Volts. All passes shall be made slowly and with care not to burn through the land or the shoulder into the lining of the pipe. The joint shall not be hotter than 100 deg. F. For large size pipe, a 5/32 inch electrode may be used, provided the temperature of the joint is held within 100 deg. F.
 5. No stress relieving of welded joints is necessary unless the pipe wall thickness warrants it. After the weld is completed, the joints in the lining shall be filled with a special compound of a wet slurry mix of the same cement used for the lining. Where accessible from the end of the pipe, the welded joint shall be swabbed with cement using a paint brush thoroughly wetted with the cement slurry.
 6. Any defects causing leaks in welded joints shall be repaired by welding without damaging the cement lining using procedures similar to that specified hereinbefore.
 7. Finished welds shall be examined as required by AWWA C206.
- E. All threads shall be clean machine cut to the dimensions of the American Standard for Pipe Threads, ASME B1.1. All burrs, dirt and foreign matter shall be removed. Screwed joints shall be made up with good quality thread compound applied to the male thread only. After having been set up, a joint must not be backed off unless the joint is completely broken, the threads cleaned and new compound applied. All joints shall be air tight. For potable water lines, an NSF61 approved pipe compound shall be used.
- F. Bolts in flanged joints or mechanical joints shall be tightened alternately and evenly. Bolt holes of flanged joints shall straddle the horizontal and vertical centerline of the pipe. Clean flanges by wire brushing before installing flanged connections.
- G. All piping shall have a sufficient number of unions, flanged joints, or coupling joints that can be dismantled to allow convenient removal of piping. Unions shall be compatible with pipe.
- H. If any defective pipe is discovered after it has been installed, it shall be removed and replaced with a sound pipe by the Contractor, at the Contractor's own expense.

3.02 TESTING

- A. All pipelines shall be tested for compliance with this Section and Sections 15050. If leaks are discovered, they shall be repaired under this Section and approved by the Engineer. Pressure and leakage tests will be required.
- B. After installation, all piping shall be flushed clean and then tested at least 1 hour at the test pressure specified above. If any joint or pipe section proves to be defective, it shall be repaired to the satisfaction of the Engineer.

3.03 DISINFECTION

- A. All pipelines that are to carry potable water shall be disinfected before they are placed into service in accordance with AWWA C651. Discharge of chlorinated water shall comply with all Federal, State and local standards. Provide sodium bisulfite for dechlorination prior to discharge.

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SECTION 15064
PLASTIC PIPE AND FITTINGS

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. Furnish all labor, materials, equipment and incidentals required and install 1/8-in to 6-in non-buried plastic piping and appurtenances as shown on the Drawings and as specified herein.
- B. Refer to Section 15050 for additional general piping requirements.

1.02 RELATED WORK

- A. Concrete work is included in Series 400.
- B. Buried piping is included under Division 2.
- C. Painting is included in Section 09902.
- D. Process Mechanical Valves and Appurtenances are included in Section 15100.
- E. Pipe Hangers and Supports are included in Section 15140.

1.03 SUBMITTALS

- A. Submit, in accordance with Section 01300, shop drawings and product data required to establish compliance with this Section. Submittals shall include the following:
 - 1. Shop drawings including piping layouts and schedules shall be submitted to the Engineer and shall include dimensioning, fittings, locations of valves and appurtenances, joint details, methods and locations of supports and all other pertinent technical specifications for all piping to be furnished.
 - 2. Shop drawing submittals for piping under this Section shall include all data and information required for the complete piping systems. All dimensions shall be based on the actual equipment to be furnished. Types and locations of pipe hangers and/or supports shall be shown on the piping layout for each piping submittal.

1.04 REFERENCE STANDARDS

- A. ASTM International.
 - 1. ASTM D1784 - Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
 - 2. ASTM D1785 - Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80 and 120.
 - 3. ASTM D2447 - Standard Specification for Polyethylene (PE) Plastic Pipe, Schedules 40 and 80, Based on Outside Diameter.

4. ASTM D2464 - Standard Specification for Threaded Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
 5. ASTM D2466 - Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
 6. ASTM D2467 - Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
 7. ASTM D2564 - Standard Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems.
 8. ASTM D2657 - Standard Practice for Heat Fusion Joining of Polyolefin Pipe and Fittings.
 9. ASTM D2665 - Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Drain, Waste and Vent Pipe and Fittings.
 10. ASTM D2855 - Standard Practice for Making Solvent-Cemented Joints with Poly (Vinyl Chloride) (PVC) Pipe and Fittings.
 11. ASTM D3261 - Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.
 12. ASTM D3311 - Standard Specification for Drain, Waste and Vent (DWV) Plastic Fittings Patterns.
 13. ASTM F437 - Standard Specification for Threaded Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
 14. ASTM F438 - Standard Specification for Socket - Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40.
 15. ASTM F439 - Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
 16. ASTM F441 - Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80.
 17. ASTM F493 - Standard Specification for Solvent Cements for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe and Fittings.
 18. ASTM F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws and Studs.
 19. ASTM F594 - Standard Specification for Stainless Steel Nuts.
- B. Plastic Pipe Institute (PPI)
1. PPI TR31 - Underground Installation of Polyolefin Piping.
- C. American National Standard Institute (ANSI)
1. ANSI B16.5 Pipe Flanges and Flanged Fittings.

- D. National Sanitation Foundation (NSF)
- E. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

- A. All plastic pipe and fittings of each type shall be furnished by a single manufacturer who is experienced in the manufacture of the items to be furnished; however, it shall not be a requirement that the pipe and fittings be manufactured by the same manufacturer, provided that the pipe and fittings are compatible in both compounding and size. The pipe and fittings shall be designed, constructed and installed in accordance with the best practices and methods and shall be suitable for the intended service.

1.06 SYSTEM DESCRIPTION

- A. Piping shall be installed in those locations as shown on the Drawings.
- B. The equipment and materials specified herein are intended to be standard types of plastic pipe and fittings for use in transporting wastewater, water, air and chemicals.
- C. Plastic piping systems shall be designed for the following conditions:
 - 1. System: Non-potable Water (NPW)
 - a. Material: Schedule 80 PVC
 - b. Fluids: Water
 - c. Pressure: Atmosphere to 90 psig
 - d. Temperature: Ambient
 - 2. System: Process Drain (PD)
 - a. Material: Schedule 80 PVC
 - b. Fluids: Low pH odor control drain water
 - c. Pressure: Atmosphere to 15 psig
 - d. Temperature: Ambient

PART 2 PRODUCTS

2.01 MATERIALS

- A. Poly (Vinyl Chloride) Pipe and Fittings - PVC
 - 1. Pipe shall be manufactured from PVC compounds meeting ASTM D1784, Class 12454-B in accordance with ASTM D1785, PVC 1120. The pipe shall have a minimum hydrostatic design stress of 2,000 psi at 73 degrees F and shall be suitable for field cutting and solvent welding. Pipe shall be of the sizes as shown on the Drawings and shall be Schedule 80 unless otherwise specified in this Section.
 - 2. Fittings shall be the socket type for solvent welded joints conforming to ASTM D2467 or ASTM D2466 where Schedule 40 pipe is shown on the Drawings. Fittings shall be manufactured from PVC compound meeting ASTM D1784, Class 12454-B. Solvent cement shall be as specified in ASTM D2564.

3. Pipe, fittings and solvent for use with potable water shall be certified by NSF in accordance with NSF Standard No. 14 and the seal shall be included on the pipe.
- B. Poly (Vinyl Chloride) Pipe and Fittings for Drain, Waste and Vent Service (DWV).
1. Pipe shall be manufactured from PVC compounds meeting ASTM D1784, Class 12454-B in accordance with ASTM D2665. The patterns, dimensions and laying lengths of fittings including adapters shall meet the requirements of ASTM D3311. Solvent cement for joining DWA pipe and fittings shall be as specified in ASTM D2564.
- C. Chlorinated Poly (Vinyl Chloride) Pipe and fittings - CPVC
1. Pipe shall be manufactured from CPVC compounds meeting ASTM D1784, Class 23447 in accordance with ASTM F441, CPVC 4120. The pipe shall have a minimum hydrostatic design stress of 2,000 psi at 73 degrees F and 500 psi at 180 degrees F and shall be suitable for field cutting and solvent welding. Pipe shall be of the sizes as shown on the Drawings and shall be Schedule 80 unless otherwise shown.
 2. Fittings shall be socket type for solvent weld joints conforming to ASTM F439 or ASTM F438 where Schedule 40 pipe is shown on the Drawings. Fittings shall be manufactured from CPVC compound meeting ASTM D1784, Class 23447. Solvent cement shall be as specified in ASTM F493.
- D. Polyethylene Pipe and Fittings - HDPE
1. Pipe shall be manufactured from High Density Polyethylene (HDPE) base resin conforming to Grade P34 (PPI PE3406 or better) in accordance with the requirements of ASTM D2447. The pipe shall have a minimum hydrostatic design stress of 630 psi at 73 degrees F and be suitable for field cutting and heat fusion joining. Pipe shall be of the sizes shown on the Drawings and shall be Schedule 80 unless otherwise shown.
 2. Fittings shall be the butt type for heat fusion joints conforming to ASTM D3261, except that Schedule 80 fittings shall meet the sustained pressure test conditions as specified for Schedule 80 pipe in Table 3 of ASTM D2447. Fittings shall be manufactured from the same HDPE base resin, conforming to Grade P34, Class C (PPI PE3406 or better), as is used to produce the pipe to which the fittings are to be joined. Both pipe and fittings shall be manufactured by the same manufacturer to assure compatibility of the piping system components.
- E. Threaded joints shall be as specified under the applicable ASTM standard for the pipe and fittings being used. Thread sealer shall be thread tape which shall be standard industrial quality Teflon, Type 1.
- F. Flanged Joints
1. Where flanged joints are shown on the Drawings, they shall be supplied with 1/8-in thick full-faced Viton-N gaskets or equal.
 2. Flange bolt spacing, number and dimensions shall conform to the requirements of ANSI B16.5. CPVC and PVC flanges shall be suitable for solvent cementing to the pipe and shall be suitable for a minimum pressure of 150 psi.

3. Bolts, nuts and washers for flanged joints shall be for corrosive service conditions and shall be ASTM F593 and F594, Type 316 stainless steel. Anti-seize compound for stainless steel bolts and nuts shall be of a molybdenum disulfide base such as Molycoat-G or equal.
- G. Fittings, specials, unions and flanges shall be of the same schedule number and manufactured of the same materials as the pipe. Whenever unions are called out on the Drawings, flanged connections may be substituted, provided that dimensional controls do not preclude use of flanges.
- H. Sleeves for plastic pipe shall be as specified in Section 15050.
- I. Expansion joints for PVC and CPVC sizes 1/2-in to 6-in shall be telescoping type as manufactured by Plastinetics, Inc.; or ASAHI/America. Expansion in pipes smaller than 1/2-in shall be accommodated with expansion loops.

2.02 SURFACE PREPARATION AND SHOP COATING

- A. All PVC and CPVC piping and fittings exposed to view shall have its surface prepared and be shop painted as specified in Section 09901, as applicable. Surface preparation and shop priming are a part of the work of this Section. Field finish painting is included in Section 09902. Assist as required in identifying pipe contents, direction of flow and all else required for proper finish painting and marking of pipe.
- B. Painting will not be required on HDPE pipe, however, marking the pipe to indicate normal direction of flow and the fluid being transported in accordance with the marking schedule included in Section 09902 shall be required as part of the work of this Section. Marking systems consisting of mylar/aluminum sandwich sheets held in place by mastic or adhesive compounds which are compatible with the HDPE resin used to manufacture the pipe shall be used to identify pipe contents and direction of flow.

PART 3 EXECUTION

3.01 INSTALLATION

- A. The installation of plastic pipe shall be strictly in accordance with the manufacturer's technical data and printed instructions.
- B. Joints for PVC and CPVC pipe shall be solvent cemented unless flanged or threaded are otherwise shown on the Drawings or are specified as other types herein. In making solvent cemented connections, clean dirt and moisture from pipe and fittings, bevel pipe ends slightly with emery cloth to remove any shoulder or burrs created by cutting of the pipe. Solvent cement joints shall be made in accordance with ASTM D2855 except that solvent cement formulated especially for and as specified above shall be used for joining CPVC pipe and fittings. Primer shall be used whenever recommended by the pipe, fitting, or cement manufacturer and in all cases for joints on pipe systems 4-in in diameter or larger. Making solvent cement joints shall not be performed and the work shall stop when the temperature, measured in the shade, is 40 degrees F and falling.
- C. Joints between PVC drain, waste and vent pipe and cast-iron soil pipe shall be made with approved mechanical compression joints designed for such use.
- D. Joints for HDPE pipe shall be butt heat fusion. Butt heat fusion joints shall be made in accordance with the requirements of ASTM D2657.

- E. Installation of valves and fittings shall be in accordance with manufacturer's instructions. Particular care shall be taken not to overstress threaded connections. In making solvent cement connections, the solvent cement or primer shall not be spilled on valves. Any cement allowed to run from joints shall be cleaned from the pipe and fittings immediately.
- F. All piping shall have a sufficient number of unions to allow convenient removal of piping and shall be as approved by the Engineer. PVC and CPVC pipe shall be installed with at least one expansion joint or loop near the center of each straight run of pipe which is 50-ft or longer with the maximum spacing between expansion joints or loops being 150-ft.
- G. Where plastic pipe passes through wall sleeves, the space between the pipe and sleeve shall be sealed with a mechanical sealing element as specified in Section 15050.
- H. All plastic pipe to metal pipe connections shall be made using flanged connections. Metal piping shall not be threaded into plastic fittings, valves, or couplings nor shall plastic piping be threaded into metal valves, fittings or couplings. Only socket to thread adaptors shall be used for threaded plastic pipe connections to other threaded devices.
- I. Concrete inserts for hangers and supports shall be furnished and installed in the concrete as it is placed. The inserts shall be set in accordance with the requirements of the piping layout and the Contractor shall verify these locations from approved piping layout drawings and the structural drawings. Pipe hangers and supports are specified in Section 15140.
- J. Due to its large coefficient of thermal expansion, HDPE pipe shall be installed at its maximum operating temperature to prevent sagging between the hangers or supports. Supports at each end of the straight HDPE pipe runs shall be of sufficient strength to develop anchoring forces adequate to oppose the tensile forces developed in the pipe due to thermal contraction. The exception to this requirement shall be for flanged HDPE connections, because, if the flanged connection is made up at the maximum operating temperature, the thermal contraction of the flange thickness will reduce the required tensile force in the flange bolts. Flanged HDPE connections shall, therefore be made up at the lowest expected operating temperature and then the entire piping system shall be brought up to the maximum operating temperature for final installation. (Note: Packing the flanges in ice may be necessary to achieve the proper installation temperature).

3.02 FIELD TESTING

- A. All pipelines shall remain undisturbed for the minimum curing or cooling time specified for each type of pipe material but no less than 8 hours to develop full curing and complete strength at all joints. All pipe systems shall be flushed clean and then subjected to a hydrostatic pressure test for 12 hours at a test pressure and temperature specified below. Testing procedures shall be as specified below and in Section 15050. Should the temperature not be attainable under hydrostatic conditions, then the test may be performed under hydro-dynamic conditions, provided that accurate measurements for loss of the test fluid can be made, or the pressure shall be proportionally increased to simulate the stresses of the higher temperature in relation to the lowest system temperature that is expected during the duration of the test. The proportionally higher test pressures shall be determined in accordance with the accepted temperature versus strength properties as published by the pipe manufacturer, PPI or other pipe material standards organization. Allowance for expansion of polyethylene pipe during the test shall be made in accordance with PPI Technical Report TR31.
- B. The test pressures and temperatures for the various pipe lines shall be as follows:
 - 1. Non-potable water: 190 psi at ambient temperature

2. Process drain water 19 psi at ambient temperature

- C. The test shall be performed by slowly filling the piping system, expelling entrapped air from all high points. The fill rate shall be controlled so that the fluid velocity within the pipe system is less than 2 fps. Upon completion of the filling process, the system shall be brought up to the specified test temperature as applicable, holding the system pressure to less than 10 percent of the test pressure. Once the system has been stabilized at the specified test temperature, the pipe should be slowly brought up to the test pressure in such a manner so as to not create shock, surge or water hammer in the pipe system. The test duration time limit shall not begin until the full pressure specified above has been reached and the system has been stabilized to within 5 percent of the test temperature. The system pressure and temperature shall be maintained to within 1/2 percent but no more than 5 percent of the specified value for the temperature and within 5 psi of the specified value for the pressure. These tolerances shall be held for the entire duration of the test. Upon completion of the test, the pressure shall be slowly removed by opening a valve or other pressure relieving device at a location remote to the location of the pressure/temperature monitoring equipment.
- D. The pressure test shall be monitored by a recording type pressure gauge for tests not requiring temperature control or a dual pen pressure/temperature recording gauge when temperature control is required. The entire test process shall be recorded, including the initial temperature stabilization and pressurization of the piping system. The record shall be continuous through the system test and shall show the final de-pressurization of the pipe system.
- E. All visible leaks detected during the pressure test shall be repaired and the pressure/ temperature test rerun. A successful test shall be a test in which no visible leaks are detected and the pipe system pressure can be maintained within 1/2 percent but no more than 5 psi of the specified value.
- F. Prior to testing, the pipelines shall be supported in an approved manner to prevent movement during the tests.

3.03 PAINTING

- A. All CPVC and PVC pipe and fittings exposed to the direct sunlight shall be field painted to provide additional UV protection. This painting shall be required whether or not marking is required and shall be in accordance with Section 09901.

END OF SECTION

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SECTION 15072
DUCTILE IRON PIPE AND FITTINGS

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. Furnish all labor, materials, equipment and incidentals required, install, and test ductile iron pipe and fittings for plant mechanical piping as shown on the Drawings and as specified herein.
- B. Mechanical piping shall include all piping and fittings installed above grade, in utility tunnel or gallery and shall exclude pipe in valve vaults, manholes, cleanouts and similar yard structures.
- C. Mechanical piping shall be installed as shown on the Drawings. Provide pipe supports, hangers and couplings as required to achieve a complete pipe system.
- D. Where the word "pipe" is used, it shall refer to pipe, fittings, or appurtenances unless otherwise noted.

1.02 RELATED WORK

- A. Materials and Equipment are included in Section 01600.
- B. Pipe Testing is included in Section 01666
- C. Painting is included in Section 09901 and Section 09902.
- D. General Piping Requirements are included in Section 15050.
- E. Valves and Appurtenances are included in Section 15100.
- F. Piping Specialties are included in Section 15120.
- G. Pipe Hangers and Supports are included in Section 15140.

1.03 SUBMITTALS

- A. Submit, in accordance with Section 01300, shop drawings and product data required to establish compliance with the Section. Submittals shall include the following
 - 1. Tabulated layout drawings showing actual pipe lengths, diameters, fittings and appurtenances.
 - 2. Prior to shipment of pipe, submit a certified affidavit of compliance from the pipe manufacturer stating that the pipe, fittings, gaskets, linings and exterior coatings for this project have been manufactured and tested in accordance AWWA and ASTM standards and requirements specified herein.

1.04 REFERENCE STANDARDS

- A. ASTM International
 - 1. ASTM C150 - Standard Specification for Portland Cement.

B. American National Standards Institute (ANSI)

1. ANSI B1.1 - Unified Inch Screw Threads (UN and UNR Thread Form).
2. ANSI B16.1 - Cast Iron Pipe Flanges and Flanged Fittings Classes 25, 125 and 250.
3. ANSI B18.2 - Square and Hex Bolts and Screws Inch Series Including Hex Cap Screws and Lag Screws.

C. American Water Works Association (AWWA)

1. AWWA C104 - Cement-Mortar Lining for Ductile-Iron Pipe and Fittings
2. AWWA C110 - Ductile-Iron and Gray-Iron Fittings. (3-in Through 48-in (80mm Through 1200mm) for Water)
3. AWWA C111 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
4. AWWA C115 - Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.
5. AWWA C116 – Protective Fusion-Bonded Epoxy Coatings for the Interior and Exterior Surfaces of Ductile-Iron and Gray-Iron Fittings.
6. AWWA C150 - Thickness Design of Ductile-Iron Pipe.
7. AWWA C151 - Ductile-Iron Pipe, Centrifugally Cast.
8. AWWA C153 – Ductile-Iron Compact Fittings for Water Service.
9. AWWA C600 - Installation of Ductile-Iron Water Mains and Their Appurtenances.
10. AWWA C606 - Grooved and Shouldered Joints.
11. AWWA C651 - Disinfecting Water Mains.

- D. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

- A. Each length of ductile iron pipe supplied for the project shall be hydrostatically tested at the point of manufacture to 500 psi for a duration of 10 seconds per AWWA C151. Testing may be performed prior to machining bell and spigot. Failure of ductile iron pipe shall be defined as any rupture of the pipe wall. Certified test results shall be furnished in duplicate to the Engineer prior to time of shipment.
- B. All ductile-iron pipe and fittings to be installed under this project shall be inspected and tested at the foundry as required by the standard specifications to which the material is manufactured. Furnish in duplicate to the Engineer sworn certificates of such tests and their results prior to the shipment of the pipe.

- C. All pipe and fittings to be installed under this Contract may be inspected at the plant for compliance with this Section by an independent testing laboratory selected by the Owner, at the Owner's expense.
- D. Inspection of the pipe and fittings will also be made by the Engineer or representative of the Owner after delivery. The pipe shall be subject to rejection at any time on account of failure to meet any of the specified requirements, even though sample pipes may have been accepted as satisfactory at the place of manufacture. Pipe rejected after delivery shall be marked for identification and shall be removed from the job.
- E. All pipe and fittings shall be permanently marked with the following information:
 - 1. Manufacturer, date.
 - 2. Size, type, class, or wall thickness.
 - 3. Standard produced to (AWWA, ASTM, etc.).

1.06 DELIVERY, STORAGE AND HANDLING

- A. See Section 01600 for general requirements.
- B. Care shall be taken in loading, transporting and unloading to prevent injury to the pipe or coatings. Under no circumstances shall the pipe be dropped or skidded against each other. Slings, hooks, or pipe tongs shall be padded and used in such a manner as to prevent damage to the exterior surface or internal lining of the pipe.
- C. Materials, if stored, shall be kept safe from damage. The interior of all piping, fittings and other appurtenances shall be kept free from dirt or foreign matter at all times.
- D. Pipe ends including flange faces shall be protected from damage. All openings shall be adequately covered with a minimum 1/2 inch thick wooden blind flange secured in place with steel fasteners or end-caps/plugs be put on pipes to prevent entrance of dirt, water and debris, and keep the pipe interior clean.
- E. Pipe shall not be stacked higher than the limits recommended by its manufacturer. The bottom tier shall be kept off the ground on timbers, rails, or concrete. Stacking shall conform to manufacturer's recommendations.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Pipe
 - 1. Ductile iron pipe shall conform to AWWA C115 and C110 See Reference Standards. Flanged and groove end pipe shall be Thickness Class 53 as per AWWA C150.
 - 2. Pipe shall be supplied in standard lengths as much as possible.
 - 3. Ductile iron pipe shall be as manufactured by U.S. Pipe; American Cast Iron Pipe Company; Clow Water Systems Company; or approved equal.

B. Joints

1. Ductile iron pipe shall have flanged joints. Flange shall be flat face type, unless otherwise noted, meeting ANSI requirements either ANSI B16.1 Class 125 or Class 250.
2. Flange gasket shall be full face type SBR per AWWA C111 to provide positive sealing for the flanged ductile iron joints. Thickness shall be 1/8-in unless otherwise indicated. The gasket materials for potable water pipe shall be certified by NSF61.
3. Assembly bolts shall be square headed carbon steel machine bolts with hexagon nuts per ANSI B18.2. Thread shall conform to ANSI B1.1. Bolt length shall be such that after joints are assembled, the bolts shall protrude through the nuts, but not more than 1/2-in.
4. Sleeve type couplings shall be Dresser Style 38 or 138 as manufactured by Dresser Industries, or equivalent products of Smith-Blair (part of Sensus), Romac Industries, or Ford Meter Box Co.
5. Flanged coupling adaptors shall be Smith-Blair (part of Sensus) Type 913, or equivalent products of Klamflex Pipe Couplings (PTY) LTD, or Robar Industries LTD.

C. Fittings

1. Pipe fittings shall be ductile iron with a minimum pressure rating of 150 psi. Fittings shall meet the requirements of AWWA C110 as applicable. Fittings shall have the same pressure rating, as a minimum, of the connecting pipe.

D. Interior Lining

1. Ductile iron pipe and fittings shall have the same type of lining as specified or indicated on the Drawings.
2. Ductile iron potable and reclaimed water pipe and fittings shall have a cement mortar lining and asphaltic seal coat in accordance with AWWA C104. The cement shall be Type II per ASTM C150.
3. Ductile iron wastewater pipe (gravity and force main) shall be lined in accordance with Austin Water Utility's Standard Products List SPL WW-534.

E. Exterior Coatings

1. Unless otherwise specified, all coatings shall be shop applied with "hold-backs" provided as required at pipe and fitting ends for satisfactory installation for joint connections in the field. Provide all necessary coating materials to perform field coating applications at joints. Unless otherwise noted, field applied coating material shall be compatible with or equal to the shop applied material. Field repair of pipe with damaged coating shall receive prior approval of the Engineer. If, in the opinion of the Engineer that the coating damage is beyond repair the pipe shall be replaced at the expense of the Contractor. All flange bearing surfaces shall be uncoated.
2. Unless otherwise specified, all exposed exterior ferrous surfaces shall be painted with an applicable paint system as specified under Division 9. Surface preparation and application thereof shall be in conformance with applicable provisions of Division 9.

F. Pipe Hangers and Supports

1. Pipe hangers and supports shall be provided at suitable distance along the pipeline regardless whether they are shown or not shown on the Drawings.
2. Pipe hangers and supports shall be as specified in Section 15140.

G. Thermal Insulation

1. Insulation shall be provided as indicated on the Drawings.
2. Pipe insulation shall be as specified in Section 15250.

PART 3 EXECUTION

3.01 PIPE INSTALLATION

A. General

1. All piping and fittings shall be installed true to alignment and rigidly supported. Anchorage shall be provided where required. Any damage to linings shall be repaired to the satisfaction of the Engineer before the pipe is installed. Each length of pipe shall be cleaned out before installation. All of manufacturer's recommendations shall be complied with.
2. The deflection at joints shall not exceed that recommended by the pipe manufacturer. Fittings, in addition to those shown on the Drawings, shall be provided, if required, in areas where conflict exists with the existing facilities.
3. When pipe cutting is acceptable to the Engineer, the cutting shall be done by abrasive saw, leaving a smooth cut at right angles to the axis of the pipe. Any damage to the lining shall be repaired to the satisfaction of the Engineer. Field cut ends shall be sealed with approved epoxy coating in accordance with manufacturer's instructions.
4. Ductile iron and fittings shall be installed in accordance with requirements of AWWA C600 modified.

B. Jointing

1. Flanged joints shall be made using gaskets, bolts, bolt studs with a nut on each end, or studs with nuts where the flange is tapped. The number and size of bolts shall conform to the same ANSI Standard as the flanges.
2. Bolts in flanged joints or mechanical joints shall be tightened alternately and evenly.
3. Sleeve type couplings and grooved joints using split ring couplings shall be installed in accordance with the procedures recommended by their respective manufacturers.

- C. All pipe and appurtenances connected to equipment shall be supported in such a manner as to prevent any strain being imposed on the equipment. When manufacturers have indicated requirements that piping loads shall not be transmitted to their equipment, submit a certification stating that such requirements have been complied with.

- D. Sleeves of proper size shall be installed for all pipes passing through floors or walls. Sleeves shall be installed as shown on the Drawings. Where indicated on the Drawings or required for liquid or gas-tightness, the pipe shall be sealed with a mechanical seal similar to Link-Seal as manufactured by EnPro Industries (PSI - Thunderline Corporation), or equal.
- E. Sleeves and wall pipes shall have thrust collar located at the mid-depth of wall.
- F. Concrete inserts for hangers and supports shall be furnished and installed as recommended by the manufacturer as shown on the Drawings or as specified herein. The inserts shall be set in accordance with the requirements of the piping layout and their locations verified from approved piping layout drawings and the structural drawings.

3.02 TESTING

- A. All piping shall be subject to acceptance tests. Provide all necessary utilities, labor and equipment for flushing and testing and dispose all waste after the test including water.
- B. Correct any leakage and repair any damage to the pipe and pipe appurtenances or to any structures resulting from, or caused by tests. All leaks shall be repaired and lines retested at no additional cost to the Owner.

3.03 CLEANING

- A. Clean the pipe by flushing with water or other means to remove all dirt, stones, pieces of wood, or other material which may have entered during the construction period. All debris shall be removed from the pipeline. The lowest segment outlet shall be flushed last to assure debris removal.

3.04 PIPE MARKING

- A. All exposed piping, exterior and interior, shall be identified by painted legend markers, directional arrow markers and number markers as required. Pipe marking colors shall contrast with pipe color for ease of visibility. Pipe marking shall match the existing markings. Letters and markers 1-1/8-in in width shall be installed on pipes under 3-in in diameter. Markers 2-1/2-in in width shall be installed on pipes 3-in in diameter and larger. Legend markers, directional arrow markers and number markers shall be placed as directed by the Engineer. Markers shall be located where pipes pass through walls or floors, at piping intersections and maximum 15-ft spacing on piping runs.
- B. Pipe marker letter legend shall be as follows:

| Service | Fluid Pipe | Marker Legend |
|---------|--|------------------|
| TSC | Thickener Scum | THICKENER SCUM |
| SL: | Thickened Sludge (In Sludge Transfer Building) | THICKENED SLUDGE |
| ST: | Sludge Transfer | SLUDGE TRANSFER |

END OF SECTION

SECTION 15083
HVAC INSULATION

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:

1. Insulation Materials:
 - a. Mineral fiber.
2. Adhesives.
3. Mastics.
4. Sealants.
5. Factory-applied jackets.
6. Tapes.

1.02 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Field quality-control reports.

1.03 QUALITY ASSURANCE

- A. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing and inspecting agency.
 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

PART 2 PRODUCTS

2.01 INSULATION MATERIALS

- A. Comply with requirements in Part 3 schedule articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. CertainTeed Corp.; Duct Wrap.
 - b. Johns Manville; Microlite.
 - c. Knauf Insulation; Duct Wrap.
 - d. Owens Corning; All-Service Duct Wrap.

- D. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory-applied FSK jacket. Factory-applied jacket requirements are specified in Paragraph 2.05 "Factory-Applied Jackets" Article.
 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. CertainTeed Corp.; Commercial Board.
 - b. Johns Manville; 800 Series Spin-Glas.
 - c. Knauf Insulation; Insulation Board.
 - d. Owens Corning; Fiberglas 700 Series.

2.02 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.

- B. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Products, Division of ITW; CP-82.
 - b. Foster Products Corporation, H. B. Fuller Company; 85-20.
 - c. ITW TACC, Division of Illinois Tool Works; S-90/80.
 - d. Marathon Industries, Inc.; 225.
 - e. Mon-Eco Industries, Inc.; 22-25.

 2. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

- C. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Childers Products, Division of ITW; CP-82.
 - b. Foster Products Corporation, H. B. Fuller Company; 85-20.
 - c. ITW TACC, Division of Illinois Tool Works; S-90/80.
 - d. Marathon Industries, Inc.; 225.
 - e. Mon-Eco Industries, Inc.; 22-25.

 2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.03 MASTICS

- A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.
 - 1. For indoor applications, use mastics that have a VOC content according to 40 CFR 59, Subpart D (EPA Method 24).
- B. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Childers Products, Division of ITW; CP-35.
 - b. Foster Products Corporation, H. B. Fuller Company; 30-90.
 - c. ITW TACC, Division of Illinois Tool Works; CB-50.
 - d. Marathon Industries, Inc.; 590.
 - e. Mon-Eco Industries, Inc.; 55-40.
 - f. Vimasco Corporation; 749.
 - 2. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm at 43-mil dry film thickness.
 - 3. Service Temperature Range: Minus 20 to plus 180 deg F.
 - 4. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.
 - 5. Color: White.
- C. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.
 - 1. Products: Subject to compliance with requirements, provide the following:
 - a. Childers Products, Division of ITW; CP-10.
 - b. Foster Products Corporation, H. B. Fuller Company; 35-00.
 - c. ITW TACC, Division of Illinois Tool Works; CB-05/15.
 - d. Marathon Industries, Inc.; 550.
 - e. Mon-Eco Industries, Inc.; 55-50.
 - f. Vimasco Corporation; WC-1/WC-5.
 - 2. Water-Vapor Permeance: ASTM F 1249, 3 perms at 0.0625-inch dry film thickness.
 - 3. Service Temperature Range: Minus 20 to plus 200 deg F.
 - 4. Solids Content: 63 percent by volume and 73 percent by weight.
 - 5. Color: White.

2.04 SEALANTS

- A. Joint Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Permanently flexible, elastomeric sealant.
3. Service Temperature Range: Minus 100 to plus 300 deg F.
4. Color: White or gray.
5. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. FSK and Metal Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Childers Products, Division of ITW; CP-76-8.
 - b. Foster Products Corporation, H. B. Fuller Company; 95-44.
 - c. Marathon Industries, Inc.; 405.
 - d. Mon-Eco Industries, Inc.; 44-05.
 - e. Vimasco Corporation; 750.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: Aluminum.
6. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.05 FACTORY-APPLIED JACKETS

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
1. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

2.06 TAPES

- A. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
 - b. Compac Corp.; 110 and 111.
 - c. Ideal Tape Co., Inc., an American Biltrite Company; 491 AWF FSK.
 - d. Venture Tape; 1525 CW, 1528 CW, and 1528 CW/SQ.
 2. Width: 3 inches.

3. Thickness: 6.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

2.07 DUCT LINER – TRANSFER DUCT

A. References

1. American Society of Testing and Materials(ASTM)
 - a. ASTM C1071
 - b. ASTM C916
 - c. ASTM G21
 - d. ASTM G22
 - e. ASTM C423
 - f. ASTM C 518
2. National Fire Protection Association (NFPA)
 - a. NFPA 90A
 - b. NFPA 90B
 - c. NFPA 259
3. Sheet Metal and Air Conditioning Contractor’s National Association (SMACNA)
 - a. HVAC Duct Construction Standards Metal and Flexible (HVAC DCS)
4. North American Insulation Manufactures Association (NAIMA)
5. Fibrous Glass Duct Liner Standard (FGDLS)

B. Duct liner shall be limited to ONLY be used in transfer ducts, and shall meet the requirements of ASTM C1071 and the additional following requirements:

1. Have a potential heat value not exceeding 3500 btu/lb when tested in accordance with NFPA 259.
2. Maximum rated velocity not less than 6000 FPM when tested in accordance with ASTM C 1071.
3. Resistant to microbial growth using a “no growth criteria” when tested in accordance with ASTM C 1138, G 21 and G22.
4. Type I - Blanket material, in roll form:
 - a. Have a maximum thermal conductivity(k-value), at 75°F (24°C) mean temperature, of .24 Btu. •in/hr. •sq.ft. •°F (0.035 W/m. •°C).

- b. Sound absorption coefficients and NRC shall meet or exceed the following when tested in accordance with ASTM C 423 using an “A” mounting.

| Thickness | Type | Absorption Coefficients @ Octave Band Frequencies (Hz) | | | | | | NRC |
|-----------|------|--|------------|------------|-------------|-------------|-------------|-----|
| | | <u>125</u> | <u>250</u> | <u>500</u> | <u>1000</u> | <u>2000</u> | <u>4000</u> | |
| 1" | 150 | .10 | .32 | .66 | .84 | .91 | .91 | .70 |

PART 3 EXECUTION

3.01 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. Wet Insulation: Any insulation that is found to be wet shall be removed from the project immediately and replaced with equal, as specified, submitted and approved. Wet insulation shall be removed and replaced any time through the end of the warranty period.

3.02 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment, ducts and fittings, and piping including fittings, valves, and specialties.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment, duct system, and pipe system as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- G. Keep insulation materials dry during application and finishing.
- H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- I. Install insulation with least number of joints practical.
- J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.

2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- L. Install insulation with factory-applied jackets as follows:
1. Draw jacket tight and smooth.
 2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
 3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
 - a. For below ambient services, apply vapor-barrier mastic over staples.
 4. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct and pipe flanges and fittings.
- M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
- P. For above ambient services, do not install insulation to the following:
1. Testing agency labels and stamps.
 2. Nameplates and data plates.
 3. Cleanouts.

3.03 DUCT LINER INSTALLATION – TRANSFER DUCTS

- A. All portions of duct designated to receive duct liner shall be completely covered with duct liner. All joints shall be neatly butted and there shall be no interruptions or gaps. Duct liner shall be installed with the black surface treatment exposed to the air stream.
- B. Duct liner shall be adhered to the sheet metal with 90% (minimum) coverage of adhesive complying with the requirements of ASTM C 916.
- C. All transverse edges that are not to receive sheet metal nosing shall be coated. Longitudinal joints shall occur at the corners of ducts. If duct size and standard duct liner product dimensions make exposed longitudinal joints necessary, such joints shall be coated with adhesive designated for duct liner application and which meets the requirements of ASTM C 916. Such joints shall be additionally secured with mechanical fasteners in accordance with NAIMA FGDLS, or SMACNA HVAC DCS as if they were transverse joints.
- D. Duct liner shall be additionally secured with mechanical fasteners complying with the requirements NAIMA FGDLS or SMACNA HVAC DCS and of the correct type for the duct liner being installed. Fasteners may be either weld-secured or impact-driven, and shall be installed perpendicular to the duct surface. Mechanical fasteners shall not compress the insulation more than 1/8" (3 mm) based on nominal insulation thickness. Fastener spacing with respect to interior duct dimensions shall be in accordance with NAIMA FGDLS or SMACNA HVAC DCS. Fastener heads or washers shall have a minimum area of 0.75 in² (484 mm²), with beveled or cupped edges to prevent their cutting into the duct liner.
- E. Where air velocities exceed 4000 fpm (20.3 m/sec), metal nosing (either channel or "zee" profile) shall be installed on upstream edges of liner duct sections.
- F. Metal nosing shall be securely installed over transverse liner edges facing the airstream at fan discharge and at any point where lined duct is preceded by unlined duct.
- G. Duct liner in roll form shall be folded and compressed in the corners of rectangular duct sections, or shall be cut and fit to assure a lapped, compressed corner joint
- H. Duct liner in sheet form shall be cut and fit to assure tight, over-lapped corner joints. Top pieces of liner shall be supported at the edges by the side pieces
- I. Any damage to the air stream surface must be repaired by coating the damaged area with adhesive or coating designed for duct liner application. Adhesive or coating shall meet requirements of ASTM C 916

3.04 PENETRATIONS

- A. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install

insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.

3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
 4. Seal jacket to wall flashing with flashing sealant.
- B. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions. Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.

3.05 MINERAL-FIBER INSULATION INSTALLATION

- A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
- B. In first subparagraph below, many manufacturers do not recommend 100 percent coverage of adhesive because of the effect on the overall insulation system's fire-performance characteristics. Verify application coverage recommendations with insulation manufacturer.
- C. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 50 percent coverage of duct and plenum surfaces.
- D. Revise first subparagraph below to allow adhesive to be omitted from top surface of horizontal rectangular ducts.
- E. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
- F. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
- G. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
- H. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
- I. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 1. Do not overcompress insulation during installation.
 2. Impale insulation over pins and attach speed washers.
 3. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

- J. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
- K. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
- L. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to 2 times the insulation thickness but not less than 3 inches.
- M. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.
- N. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
- O. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.
- P. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
 - 1. In first subparagraph below, many manufacturers do not recommend 100 percent coverage of adhesive because of the effect on the overall insulation system's fire-performance characteristics. Verify application coverage recommendations with insulation manufacturer.
 - 2. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
 - 3. Revise first subparagraph below to allow adhesive to be omitted from top surface of horizontal rectangular ducts.
 - 4. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
 - 5. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
 - b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.

- d. Do not overcompress insulation during installation.
 - e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
- Q. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
1. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
 2. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to 2 times the insulation thickness but not less than 3 inches.
 3. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
 4. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.06 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation:

1. Indoor, concealed supply and outdoor air.
2. Indoor, exposed supply and outdoor air.
3. Indoor, concealed return located in non-conditioned space.
4. Indoor, exposed return located in non-conditioned space.
5. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
6. Indoor, exposed exhaust between isolation damper and penetration of building exterior.

END OF SECTION 15083

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SECTION 15100
PLANT PROCESS MECHANICAL VALVES AND APPURTENANCES

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. Furnish all labor, materials, equipment and incidentals required and install complete and ready for operation and test all non-buried valves as shown on the Drawings and as specified herein.
- B. The equipment shall include the following:
 - 1. Valve Actuators – General
 - 2. Valve Actuators - Powered
 - 3. Gate Valves (3-in and larger)
 - 4. Plug Valves
 - 5. Ball Valves
 - 6. Swing Type Check Valves
 - 7. Plastic Valves
 - 8. Solenoid Valves
 - 9. Hose End Valves
 - 10. Air and/or Air/Vacuum Valves (General and/or Sewage Use)

1.02 RELATED WORK

- A. Water Valves (buried) is included in Section 511S.
- B. Valve tags are included in Section 01170.
- C. Field painting and pipe marking are included in Section 09902.
- D. Valves on all HVAC systems, plumbing and/or chemical systems, not noted herein are included in their respective sections of Division 15.
- E. Piping general requirements and testing are included in Section 15050.
- F. Piping specialties are included in Section 15120.
- G. Pipe hangers and supports are included in Section 15140.
- H. Instrumentation and Electrical, not specified herein, are included in Divisions 13, 16 and 17.

- I. Certain appurtenances for individual types of pipe or systems are specified with the specific type of pipe or system. However, additional items are specified in Section 15120.
- J. Certain items similar to those specified in this Section may be specified to be furnished and installed with individual equipment or systems. In case of a conflict, those individual equipment or system requirements shall govern.
- K. Electric and pneumatic valve operators of all types, rate of flow controllers (including modulating valves and operators) and other types of valves which are part of the automated instrumentation (such as some solenoid valves) if not included herein are included in Division 16 and 17. Valve operators shall, however, be mounted at the factory on the valves as specified herein, as part of the work of this Section.

1.03 SUBMITTALS

- A. Submit, in accordance with Section 01300, materials required to establish compliance with this Section. Submittals shall include the following:
 - 1. Certified drawings showing all important details of construction and dimensions.
 - 2. Descriptive literature, bulletins and/or catalogs of the equipment.
 - 3. The total weight of each item.
 - 4. A complete bill of materials.
 - 5. Additional submittal data, where noted with individual pieces of equipment.
 - 6. Location of the valve and actuator manufacturing facility.
 - 7. Electrical characteristics and wiring diagrams including but not limited to voltage, load in kW, Hp or FLA and phase.
- B. Test Reports
 - 1. Provide certified hydrostatic test data, per manufacturer's standard procedure or MSS-SP-61 for all valves.
- C. Certificates
 - 1. For each valve specified to be manufactured, tested and/or installed in accordance with AWWA and other standards, submit an affidavit of compliance with the appropriate standards, including certified results of required tests and certification of proper installation.
- D. Manufacturer's Installation and Application Data
- E. Operating and Maintenance Data
 - 1. Operating and maintenance instructions shall be furnished to the Engineer as provided in Section 01730. The instructions shall be prepared specifically for this installation and shall include all required cuts, drawings, equipment lists, descriptions and other information required to instruct operating and maintenance personnel unfamiliar with such equipment.

2. Submit the valve schedule and valve identification numbers as specified in Section 01170.

F. Warranty

1. The Contractor shall obtain from each manufacturer its warranty that the equipment shall be warranted for a period of 1 year from the date of Substantial Completion, as defined under the General Conditions, Section 00700 and specified in Section 01740, to be free from defects in workmanship, design or material. If the equipment should fail during the warranty period due to a defective part(s), the part(s) shall be replaced and the unit(s) restored to service at no additional cost to the Owner.

1.04 REFERENCE STANDARDS

A. American Society for Testing and Materials (ASTM)

1. ASTM A48 - Standard Specification for Gray Iron Castings.
2. ASTM A126 - Standard Specification for Gray Iron Castings for Valves, Flanges and Pipe Fittings.
3. ASTM A159 - Standard Specification for Automotive Gray Iron Castings.
4. ASTM A240 - Standard Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet and Strip for Pressure Vessels.
5. ASTM A276 - Standard Specification for Stainless Steel Bars and Shapes.
6. ASTM A436 - Standard Specification for Austenitic Gray Iron Castings.
7. ASTM A536 - Standard Specification for Ductile Iron Castings.
8. ASTM B30 - Standard Specification for Copper-Base Alloys in Ingot Form.
9. ASTM B62 - Standard Specification for Composition Bronze or Ounce Metal Castings

B. American Water Works Association (AWWA)

1. AWWA C111 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
2. AWWA C500 - Metal-Seated Gate Valves Supply Service
3. AWWA C504 - Rubber-Seated Butterfly Valves
4. AWWA C507 - Ball Valves, 6-in Through 48-in (150mm Through 1200mm)
5. AWWA C508 - Swing-Check Valves for Waterworks Service, 2-in (50mm Through 24-in (600mm) NPS
6. AWWA C509 - Resilient-Seated Gate Valves for Water Supply Service
7. AWWA C511 - Reduced-Pressure Principle Backflow-Prevention Assembly

8. AWWA C517 - Resilient-Seated Cast-Iron Eccentric Plug Valves
 9. AWWA C540 - Power-Actuating Devices for Valves and Sluice Gates
 10. AWWA C550 - Protective Epoxy Interior Coatings for Valves and Hydrants
 11. AWWA C800 - Underground Service Line Valves and Fittings
- C. American National Standards Institute (ANSI)
1. ANSI B2.1 - Specifications, Dimensions, Gauging for Taper and Straight Pipe Threads (except dry seals).
 2. ANSI B16.1 - Cast Iron Pipe Flanges and Flanged Fittings
 3. ANSI B16.10 - Face-to-Face and End-to-End Dimensions of Valves
 4. ANSI B16.104 - Butterfly Valves
- D. American Iron and Steel Institute (AISI)
- E. Manufacturer's Standardization Society of the Valve and Fittings Industry (MSS)
1. MSS-SP-61 - Pressure Testing of Steel Valves.
 2. MSS-SP-67 - Butterfly Valves.
 3. MSS-SP-70 - Cast Iron Gate Valves, Flanged and Threaded Ends.
 4. MSS-SP-71 - Cast Iron Swing Check Valves, Flanges and Threaded Ends.
 5. MSS-SP-72 - Ball Valves with Flanged or Butt-Welding Ends for General Services.
 6. MSS-SP-78 - Cast Iron Plug Valves, Flanged and Threaded Ends.
 7. MSS-SP-80 - Bronze Gate, Globe, Angle and Check Valves.
 8. MSS-SP-82 - Valve Pressure Testing Methods
 9. MSS-SP-98 - Protective Coatings for the Interior of Valves, Hydrants and Fittings.
- F. National Electrical Manufacturers Association (NEMA)
- G. Underwriters Laboratories (UL)
- H. Factory Mutual (FM)
- I. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

A. Qualifications

1. Valves and appurtenances shall be products of well-established firms who are fully experienced, minimum 10 years, reputable and qualified in the manufacture of the particular equipment to be furnished. Bonds in lieu of experience will not be acceptable.
2. The equipment shall be designed, constructed and installed in accordance with the best practices and methods and shall comply with this Section as applicable.
3. All units of the same type shall be the product of one manufacturer.

B. Certifications

1. The manufacturers shall furnish an affidavit of compliance with Standards referred to herein as specified in Paragraph 1.03C above. Refer to PART 3 for testing required for certain items in addition to that required by referenced standards.

C. Provide the services of a qualified and factory-trained service representative of the manufacturer to provide initial settings, operational and maintenance instruction, for a 1 day, 8-hour period for:

1. Valve motor operators.
2. Valve pneumatic operators
3. Pressure regulating valves.

D. Inspection of the units may be made by the Engineer or other representative of the Owner after delivery. The equipment shall be subject to rejection at any due to failure to meet any of the specified requirements, even though submittal data may have been accepted previously. Equipment rejected after delivery shall be marked for identification and shall be removed from the job site at once.

1.06 SYSTEM DESCRIPTION

- A. All of the equipment and materials specified herein is intended to be standard for use in controlling the flow of wastewater, wastewater sludges, air and chemicals, plant water, protected water and potable water as noted on the Drawings.
- B. Valves, appurtenances and miscellaneous items shall be installed as shown on the Drawings and as specified, so as to form complete workable systems.
- C. Unless otherwise noted all powered valve operators shall have:
 1. Metallic valves larger than 3-in: electric operators 460 Volt, 3 Phase, 60 Hz.
 2. Solenoid valves and plastic control valves: 120 volt, single phase, 60 Hz, NEMA 4 enclosure for unclassified space, NEMA 4X for corrosive space, continuous duty Class F coils and manual operator. Provide a valved bypass (globe style) for each solenoid valve. Enclosures for solenoid valves shall be NEMA 7 (explosion proof) UL listed for Class I Division 1, Group

C & D for all classified areas. See Electrical Area Classification Site Plans for specific locations.

3. See other paragraphs for additional requirements.

1.07 DELIVERY, STORAGE AND HANDLING

A. Reference is made to Section 01600 for additional information.

B. Packing and Shipping

1. Care shall be taken in loading, transporting and unloading to prevent injury to the valves, appurtenances, or coatings. Equipment shall not be dropped. All valves and appurtenances shall be examined before installation and no piece shall be installed which is found to be defective. Any damage to the coatings shall be repaired as acceptable to the Engineer.
2. Prior to shipping, the ends of all valves shall be acceptably covered to prevent entry of foreign material. Covers shall remain in place until after installation and connecting piping is completed.
 - a. All valves 3-in and larger shall be shipped and stored on site until time of use with wood, plywood, or plastic covers on each valve end.
 - b. Valves smaller than 3-in shall be shipped and stored as above except that heavy cardboard covers may be used on the openings.
 - c. Rising stems and exposed stem valves shall be coated with a protective oil film which shall be maintained until the valve is installed and put into use.
 - d. Any corrosion in evidence at the time of acceptance by the Owner shall be removed, or the valve shall be removed and replaced at no cost to the Owner.

C. Storage and Protection

1. Special care shall be taken to prevent plastic and similar brittle items from being directly exposed to the sun, or exposed to extremes in temperature, to prevent deformation. See the individual piping sections and manufacturer's information for further requirements.

1.08 MAINTENANCE

- A. Special tools including packing maintenance hardware and the manufacturer's standard spare parts, if required for normal operation and maintenance, shall be supplied with the equipment in accordance with Sections 01170 and 01730 and where noted, as specified herein.
- B. Provide all special tools required for normal maintenance. Tools shall be packaged in a steel case, clearly and indelibly marked on the exterior to indicate equipment for which tools are intended.
- C. Provide to the Owner a list of all spare and replacement parts with individual prices and location where they are available. Prices shall remain in effect for a period of not less than 1 year after start-up and final acceptance.

PART 2 PRODUCTS

2.01 MATERIALS AND EQUIPMENT - GENERAL

- A. Reference is made to Division 1 for additional requirements, including nameplates, provisions for temporary pressure gauges, protection against electrolysis and anchor bolts.
- B. The use of a manufacturer's name and/or model or catalog number is for the purpose of establishing the standard of quality and general configuration desired.
- C. Valves and appurtenances shall be of the size shown on the Drawings or as noted and as far as possible equipment of the same type shall be identical and from one manufacturer.
- D. Valves and appurtenances shall have the name of the maker, nominal size, flow directional arrows, working pressure for which they are designed and standard referenced, cast in raised letters or indelibly marked upon some appropriate part of the body.
- E. Unless otherwise noted, items shall have a minimum working pressure of 150 psi or be of the same working pressure as the pipe they connect to, whichever is higher and suitable for the pressures noted where they are installed.
- F. Joints, size and material - unless otherwise noted or required by the Engineer:
 - 1. Except where noted, all joints referred to herein shall be of the same type, nominal diameter, and material and with a minimum rating equal to the pipe or fittings they are connected to.
 - 2. Valves and appurtenances shall be of the same nominal diameter as the pipe or fittings they are connected to unless otherwise specified.
 - 3. All valves exposed to view, or in vaults.
 - a. 2-1/2-in and smaller - threaded or soldered ends as required.
 - b. 3-in - threaded or flanged as shown.
 - c. 4-in and larger - flanged ends.
- G. Provide all special adaptors as required to ensure compatibility between valves, appurtenances and adjacent pipe.
- H. Valves and actuators located outdoors but not within a building; within maximum 2-ft above liquid; in vaults; or where otherwise noted shall be designed for submerged service where water may completely submerge the valve and operator. All other units shall be as a minimum weather tight. Valves and actuators designed for submerged service shall have Type 316 stainless steel bolts and hardware.

2.02 VALVE ACTUATORS - GENERAL

- A. See Paragraph 2.01H above for submergence requirements.
- B. The valve manufacturer shall supply and integrally, rigidly mount all actuators, including any type of manual or powered actuators, on valves at the factory. The valves and their individual actuators shall be shipped as a unit.

- C. Unless otherwise noted, valves shall be manually actuated; all valves shall have an operating wheel, handle or lever mounted on the operator; valves with operating nuts shall have a non-rising stem with an AWWA 2-in nut. At least two tee handles shall be provided for all operating nuts. Furnish handwheel actuators on all manually actuated valves 6-in diameter and larger unless otherwise indicated on the Contract Documents.
- D. Except as otherwise shown on the Drawings or specified herein, all valves 3-in diameter or larger, with the valve center line located 7-ft or more above the operating floor, shall be provided with ductile iron chain wheel operators complete with chain guides, attachment sets and hot dipped galvanized steel chain, which loop within 4-ft of the operating floor.
- E. All actuators shall be capable of moving the valve from the full open to full close position and in reverse and holding the valve at any position part way between full open or closed.
- F. Each operating device shall have cast on it the word "OPEN" and an arrow indicating the direction of operation. The direction to open the valve shall be counterclockwise.
- G. Floor boxes for operating nuts recessed in concrete shall be standard cast iron type, cast-in-place, with fastening top by Clow, Troy or equal.
- H. Stem guides shall be high strength cast or ductile iron and shall be of the adjustable wall bracket type, bronze bushed, with maximum spacing of 10-ft as manufactured by Clow; Rodney Hunt, Troy or equal. Extended operating nuts and/or stems shall have universal joints and pin couplings, if longer than 10-ft and a rating of at least five times the maximum operating torque. Stem adaptors shall be provided.
- I. Where required by the installation, or as specified, provide the following: extended stem; floor stand and handwheel; position indicator and etched or cast arrow to show direction of rotation to open the valve; resilient, moisture-resistant seal around stem penetration of slab.
- J. Gear Actuators
 - 1. Unless otherwise noted, gear actuators shall be provided for the following: all valves equal to and larger than 8-in nominal diameter; where specified and/or indicated on the Drawings; where manual operator effort is greater than 40 ft-lbs rim pull.
 - 2. Gear actuators shall be of the worm or helical gear type with output shaft perpendicular to valve shaft, having a removable hand wheel mounted on the output shaft. Unless noted they shall conform to AWWA C504, but except with butterfly valves, need not be certified.
 - 3. Actuators shall be capable of being removed from the valve without dismantling the valve or removing the valve from the line.
 - 4. Gearing shall be machine-cut steel designed for smooth operation. Bearings shall be permanently lubricated, with bronze bearing bushings provided to take all thrusts and seals and to contain lubricants. Housings shall be sealed to exclude moisture and dirt, allow the reduction mechanisms to operate in lubricant and be of the same material as the valve body.
 - 5. Manual operator input effort to the handwheel shall be a maximum of 40 ft-lbs for operating the valve from full open to full close, under any conditions. Gear actuators shall indicate valve position and have adjustable stops. Maximum handwheel size shall be 24-in diameter.

- K. Additional valve actuators are included with the individual valve types and as noted in Paragraph 1.02 above.
- L. All position indication and direction of opening arrows shall be embossed, stamped, engraved, etched or raised decals.
- M. Unless otherwise noted, all valves larger than 3-in nominal diameter shall be provided with position indicators at the point of operation. Valves smaller than 3-in shall have position indicators on their handwheels or levers.

2.03 VALVE ACTUATORS - POWERED

- A. Electrical actuators for valves shall be furnished as part of this Section, shall comply with AWWA C540 and the provisions of Division 16 and 17 and shall be capable of mounting in any position. Actuators shall be suitable for a 480 Volt, 3 phase, 60 Hz power supply unless otherwise indicated in the Contract Documents.
- B. Operators for quarter turn valves 3-in and smaller shall consist of the motor, reduction gearing, local position indicator, position limit switches, provision for manual override and motor thermal and electronic control protection. Actuators shall utilize a reversible permanent split capacitor motor, suitable for operation on a 120 Volt, single phase, 60 Hz power supply. Each actuator shall include a disengageable manual override.
- C. Unless otherwise noted all electric or other powered actuators shall utilize worm gear or helical gearing for all size valves. Operating speed shall not exceed 30 seconds from full open to full close.
- D. Motorized actuators shall be factory wired with major components as follows: motor, reversing motor starter, control power transformer, pilot devices (push buttons, selector switches, position lights), torque and position limit switches and status lights, position and status contacts, thermostatically controlled space heater, and terminals. The actuator shall be a self-contained, totally enclosed unit including reduction gearing, detachable drive bushing, thrust bearing, and emergency hand wheel local position indicator. Actuator enclosures shall be NEMA 7 (explosion proof) U.L. listed for Class I, Division 1, Group C & D where required. See area classification plans on the Electrical Drawings. All other enclosures shall be NEMA 4 for unclassified space and NEMA 4X for corrosive space. Actuator housings shall be of cast aluminum.
- E. Where actuators are mounted below the finish floor or 6-ft or greater above the finish floor, provide local pushbutton stations in separate enclosures for remote mounting at easily accessible locations. Pushbutton station enclosures shall be Type 316 stainless steel. Control circuits shall be 120-volt, single phase, 60 Hz, supplied by control power transformer. Pushbutton station enclosures shall be NEMA 7 (explosion proof) UL listed for Class I, Division 1, Group C & D where required. See area classification plans on the Electrical Drawings. All other enclosures shall be NEMA 4 for unclassified space and NEMA 4X for corrosive space. Pushbutton stations shall include indicating lights for Open (Red), Close (Green), Power On (White) and Overload (Orange).
- F. Furnish position indicating switches on all electric actuated valves. Switches shall be single pole, double throw, at either limit of open or close or both limits. Switches shall be enclosed in a NEMA 4X enclosure for corrosive space and NEMA 4 for unclassified space and contacts shall be rated 10 Amps at 120 VAC except switch enclosures which shall be NEMA 7 (explosion proof) UL listed for Class I, Division 1, Group C & D where required. See area classification plans on the Electrical Drawings.

- G. The Contractor's attention is specifically directed to the Division 17 for details on controls requirements and to the Process Instrumentation and Control (P&ID) Drawings. Note that the electrical controls indicated on the Drawings and in this Section are based on utilizing Limitorque actuators. Actuators shall be Limitorque Accutronix MX series. Equal products by EIM Controls, Inc. Rotork Controls, Inc. or AUMA Actuators Inc., may be utilized, but any modifications required to the control and/or wiring indicated in these Contract Documents, in order to use other equipment, shall be the Contractor's responsibility.
- H. Electric operators arranged for open-close operation shall open and close the valve between the limit switch settings in response to local operation of an Open-Stop-Close pushbutton station furnished and mounted as an integral part of the controls or from a remote signal. The controls shall consist of a combustion air circuit breaker and reversing starter. A lockable Local-Off-Remote selector switch shall also be provided to allow response to remote Open-Stop-Close commands. Provide and label red and green indicating lights on the operator. Red light on when valve is completely open; green light, when valve is completely closed; both red and green lights on during operation at intermediate positions or when operator is stopped at any intermediate position. Provide white power on light and amber torque overload light. Provide a normally open dry contact for remote indication that the Local-Off-Remote is in the "Remote" position and in the "Local" position.
- I. Electric operators arranged for modulating control shall provide Open and Close control in response to a 4-20 mADC remote signal, utilizing a completely solid state modulating control.
1. The operator shall utilize a 480 VAC, 3 Phase, reversing motor controlled by a solid state reversing starter to position the gate. Overshoot of the operator shall be controlled by pulsing the motor once the gate position approaches the desired position to decelerate the motor speed.
 2. When in Remote, the controller shall compare the incoming 4-20 mADC signal from an external source with an integral position feedback signal generated by a mechanical potentiometer connected to the valve stem drive, and shall drive the operator to match these signals. The controller shall have an adjustable dead band to determine the difference between the reference signal and position signal at which the operator will readjust position. The controller shall output a 4-20 mADC signal to an external source for feedback position.
 3. The controller shall incorporate adjustments for span, zero, gain, and dead band. Power supply shall be 480 Volts, 3 Phase, 60 Hz. A control power transformer for 110 Volt, single phase control power shall be provided.
 4. A Hand-Off-Automatic selector switch and a spring return Open-Stop-Close selector switch shall be provided as an integral part of the controls.
 5. Normally open dry contacts shall be provided in full open and full close position indication.
 6. Provide a normally open dry contact for remote indication that the Local-Off-Remote is in the "Remote" position.
- J. The handwheel drive shall permit manual operation in a reasonable time, related to valve size. Failure of motor drive or gearing should not prevent manual operation. Handwheel shall not operate when motor operates. Motor shall be unable to operate when handwheel is operating.
- K. Continuous mechanical dial indication of valve end positions shall be incorporated.

- L. Electric operators for plastic valves shall have a 115 VAC, single phase, 60 Hz, reversing motor with integral thermal overload protection with automatic reset, 100 percent duty cycle, 2 single pole double throw open and close limit switches, declutchable manual override, mechanical visual position indicator, permanently lubricated gear train, stainless steel output shaft, and contacts for remote open/close position indication. Enclosure shall be rated NEMA 4X. Control stations shall be furnished under Division 16 for remote operation.

2.04 GATE VALVES (3-IN AND LARGER)

- A. General Requirements. Valves shall be solid wedge, or resilient seated, as indicated on the Drawings or as specified herein for class of service.
 - 1. Unless otherwise specified below, these requirements shall apply to all gate valves 3-in and larger.
 - 2. Gate valves shall meet the requirements of AWWA C515 and AWWA C509 as applicable to the type of valve specified.
 - 3. Submerged valves shall be furnished with mechanical joints and stainless steel hardware; non-rising stem design with 2-in operating nut.
 - 4. Exposed valves shall be furnished with Class 125 flanged ends and provided with outside screw, yoke and handwheel operator.
 - 5. All-metal valves shall be manufactured of ASTM A126 Cast or Ductile Iron, Class B, with bronze mounting design.
 - 6. Rising stem valves shall be sealed with adjustable and replaceable packing; valve design must permit packing replacement under operating system pressures with only moderate leakage.
 - 7. Non-rising stem valves shall use a double O-ring stem seal, except that packing shall be used where geared operators are required.
 - 8. Except as otherwise specified, valves shall be rated for a working pressure of 150 psi:
 - a. All valve bodies shall be hydrostatically tested to at least twice the rated working water pressure. In addition, valves shall be seat-tested, bi-directional at the rated working pressure, with seat leakage not to exceed one fluid ounce per inch of valve diameter per hour. Provide certificates of testing.
 - 9. Flanged valves to have face-to-face dimensions per ANSI B16.10 and flanges per ANSI B16.1.
 - 10. All bonnet and packing gland bolts shall be zinc or cadmium electroplated steel or stainless steel; packing gland bolts shall have bronze nuts.
 - 11. All valves shall be marked per AWWA Standards, including name of manufacturer, valve size working pressure and year of manufacture.
 - 12. Unless otherwise indicated, valves 12-in and smaller shall be capable of installation in the vertical or horizontal position, and sealing in both directions at the rated pressure.
 - 13. Valve operation shall be counterclockwise. Provide permanent label showing "OPEN" and arrows.

14. Metal-seated valves shall be coated internally and externally with an asphaltic varnish, per AWWA C500. Resilient seated valves shall be coated, interior and exterior, with fusion bonded epoxy per AWWA C550.

B. Valve Applications

1. Valves for Potable, Wastewater, Plant Water or Protected Water Service
 - a. Resilient seated design manufactured by American Flow Control; Mueller; Kennedy Valve; M&H; or Clow.

C. Valve Requirements

1. Resilient Seated
 - a. Conform to AWWA C509 and C515. Also UL and FM approved.
 - b. Internal and external epoxy coating of valve body, including bonnet, per AWWA C550.
 - c. Gate shall be encapsulated with synthetic rubber or EPDM. It shall be bonded and vulcanized in accordance with ASTM B429 Method B.
 - d. No recesses in valve body.

D. Tapping Valves and Sleeves

1. Tapping valves shall comply with the same requirements as solid wedge gate valves except they shall have the flanged end and port opening modified for tapping service. Valves shall be capable of passing a full nominal sized cutter without damage to the valve. The tapping sleeve shall be gray cast iron or ductile iron mechanical joint type with the outlet flange conforming to MSS-SP-60.

2.05 PLUG VALVES

- A. Plug valves shall be of the offset disc eccentric type, 1/4 turn, non-lubricated, serviceable (able to be repacked) under full line pressure and capable of sealing in both directions at the rated pressure. The disc shall be completely out of the flow path when open. Plug valves specified herein shall be by Golden Anderson; Clow; Keystone; or Val-Matic. All manufacturers named or otherwise, must comply completely with this Section.
 1. All size plug valves shall have a minimum port area of 80 percent when measured by the percent cross-sectional area of equivalent size (nominal same diameter) pipe.
 - a. The 4-inch plug valve dedicated to scum service shall have a minimum port area of 100 percent when measured by percent cross-sectional area of equivalent size (nominal same diameter) pipe.
 2. All plug valves for whatever service, shall be capable of passing "pigging" cleaning equipment (using a Girard or similar cleaning pig of full nominal pipeline diameter) in either direction and manufacturer shall so certify that this may be done without the use of special equipment.

- B. Valves shall be rated at minimum 175 psi WOG (Water, Oil and Gas) working pressure for sizes 4-in to 12-in inclusive and at minimum 150 psi WOG working pressure for sizes 14-in and larger.
1. All plug valves under this Paragraph shall be performance, leakage and hydrostatically tested in accordance with AWWA C517, except as modified herein.
 2. At the above rated minimum working pressures, the valves shall be certified by the manufacturer as permitting zero leakage for a period of at least 1/2 hour with pressure applied in either direction.
 3. At the direction of the Engineer, the valve manufacturer may be requested to perform a valve seat leakage test, witnessed by the Engineer to prove compliance with this Section.
- C. Valve bodies shall be of cast iron, 30,000 psi tensile strength, ASTM A126, Grade B, or of ductile iron, ASTM A536 and of the top entry, bolted bonnet design, cast with integral flanges conforming to the connecting piping. All exposed bolts, nuts and washers shall be zinc or cadmium-plated, except for buried or submerged valves, which shall have Type 316 stainless steel hardware.
- D. The valve disc (plug) shall:
1. Be cast iron ASTM A126, Grade B, or ductile iron, ASTM A536, Grade 65-45-12.
 2. Be removable without removing the valve from the line.
 3. Have an integral upper and lower shaft which shall have seals on the upper and lower journals to prevent entrance of solids into the journals.
 4. Be one piece for all valves up to 14-in and maximum two piece for larger valves.
- E. Shaft bearings shall be permanently lubricated, rigidly backed, Type 316 stainless steel at both upper and lower stem journals. The operator shaft shall have easily replaceable seals, which shall be externally adjustable and repackable without removing the bonnet from the valve, or shall have self-adjusting packing.
- F. The valve seating surface shall provide full 360 degree seating by contact of a resilient seating material on the disc mating with welded-in high nickel content overlay seating surface in the body.
1. The seating design shall be resilient and of the continuous interface type having consistent opening and closing torques and shall be non-jamming in the closed position. Screw-in seats shall not be acceptable.
 2. Discs (plugs) shall have a full resilient facing of neoprene or Buna-N.
- G. The methods of mounting the actuator to the valve shall provide an air gap between the two. Actuator shall clearly indicate valve position and an adjustable stop shall be provided. Construction of actuator housing shall be semi-steel. Hardware on actuators shall be of the same materials as the valves.
- H. Unless otherwise required, due to location or operation, each valve -in and smaller shall be provided with its own securely attached lever. Provide adjustable limit stops for both opening and closing and a clearly marked position indicator.

- I. Plug valves shall be installed so that the direction of flow through the valve and the shaft orientation is in accordance with the manufacturer's recommendations. Unless otherwise noted or required by the location of the valve, shaft shall be horizontal, with plug opening up.
- J. Submerged plug valves shall be furnished with 2-in operating nuts. The valves shall be provided with a geared valve actuator mounted on top of a cast iron offset floor stand, connected to the valve by a stem extension/torque tube. The stem extension/torque tube shall be supported as required by adjustable stem guides of high strength cast iron.

2.06 BALL VALVES

A. Ferrous Ball Valves

- 1. Ball valves, greater than 3-in diameter, for water service shall be ductile iron body or carbon steel, split body, full bore, fire safe, flanged, rated for the operating pressure of 150 psi and shall comply with AWWA C507.
- 2. Valve shall consist of a Type 316 solid stainless steel ball with full 100 percent port opening that rotates on a fixed axis with upper and lower trunnions and Teflon bearings. Valve shall be a bi-directional flow valve with independent sealing capability on each side of the ball for tight shut-off. Valve seats shall be nylon with Buna-N seals. Valve shaft shall be minimum Type 304 stainless steel
- 3. In order to determine the position of the ball within the valve (open or closed), there shall be an easily visible, permanent indicator located conspicuously on the top of the valve. Valves shall be operated by a manual, handwheel operated, gear actuator as specified above in Paragraph 2.02.
- 4. Valves shall be as manufactured by KF Valves, DEMCO, or Jamesbury.

B. Ball valves for water piping and air piping less than or equal to 3-in diameter shall be manually actuated unless otherwise shown on the Drawings, bronze, resilient seated, regular port, threaded two piece body, blow-out proof stem design type valves with soldered ends. The body and cap shall be of brass, ASTM B30, the ball and stem of Type 316 stainless steel and the seats and seals of PTFE. The valves shall have full floating ball and shall be non-lubricated. Valve seats shall be easily accessible and replaceable. Air valves shall be rated for 200 degree F working temperature. Valves shall be rated to 250 psi and shall be as manufactured by Hammond Valve, Jamesbury; or WKM.

C. Ball valve on stainless steel piping systems shall be manually actuated unless otherwise shown on the Drawings, resilient seated, standard port, threaded two piece body, blow-out proof stem design type valves with threaded ends. Valve body, ball, stem and all trim materials shall be a Type 316 stainless steel and the seats and seals of PTFE. The valves shall have full floating ball and shall be non-lubricated. Seats and seals shall be easily accessible and replaceable. Valves shall be rated to 150 psi and shall be as manufactured by Hammond Valve, Jamesbury or WKM.

2.07 SWING TYPE CHECK VALVES

- A. Check valves for metallic lines of 2-in to 24-in diameter shall be swing type and shall meet the requirements of AWWA C508. The valves shall be cast or ductile iron body, bronze mounted, single disc, 150 psi working water pressure, non-shock and hydrostatically tested at 300 psi.

1. When there is no flow through the line, the disc shall hang lightly against its seat in practically a vertical position. When open, the disc shall swing clear of the waterway.
 2. Check valves shall have bronze seat and body rings, extended bronze or stainless steel hinge pins and bronze nuts on the bolts of bolted covers.
 3. Valves shall be so constructed that disc and body seat may easily be removed and replaced without removing the valve from the line. Valves shall be fitted with an extended hinge arm with outside lever and weight. The position of the weight shall be adjustable. Various weights shall be provided and installation approved by the Engineer. Lever shall be installed to the horizontal in the closed position, for both horizontal and vertical pipeline installations.
 4. Valves shall be supplied with an air-filled cushion attached to the body and lever arm designed to control "slamming" of the valve.
 5. Check valves shall be by Golden Anderson, American-Darling; M&H; Clow; Mueller; or APCO.
 6. Check valves 2-in and smaller for installation in copper and steel pipes shall be bronze, swing type, 125 lb with solder or screwed ends.
- B. Limit switches: Provide limit switches on manually operated valves where indicated on the Drawings:
1. Limit switches: Heavy-duty, industrial grade, oil-tight, with not less than 2 auxiliary contacts.
 2. Rating: Rated for 10 amps, 120 volts alternating current.
 3. Enclosure: NEMA 4X enclosure and with stainless steel levers and arms. Provide switch with NEMA 7 enclosure when switch is located within areas with NEC Class 1, Division 1 or Class 1, Division 2 designations as indicated on the Drawings.
 4. Switches shall be mounted and tested on the valves at the factory.

2.08 PLASTIC VALVES

A. General

1. All valves shall be certified as completely compatible with the intended and specified service; compatibility shall apply to the material of the valve and internal components, including all seals, gaskets, O-rings and washers; solvents and primers used in valve joint make-up shall be specifically in conformance with the written instructions of the valve supplier. Service chemicals and service conditions are shown in the piping sections in Division 15.
2. Except as otherwise specified valve ends shall be socket-type designed for solvent welding. The valve manufacturer shall provide specific recommendations for solvent and primer.
3. Valve material shall be the same as the piping service except as specified.
 - a. PVC shall be Type 1, Grade 1, per ASTM D1784 classification, made from unplasticized polymer, and generally suitable for service to 120 degrees F.
 - b. The manufacturer of the valves shall retain material source quality documentation and shall furnish it to the Engineer upon request.

4. Unless otherwise specified:
 - a. O-rings, valve seats and stem seals shall be AFLAS TFE elastomer. Alternative materials may not be substituted without complete documentation provided to the Engineer of service suitability.
 - b. Gaskets shall be made from PTFE-bonded sheet material, GORE-TEX manufactured by W.L. Gore & Associates; AV Low-Torque gaskets by Asahi of America or equal.
 - c. Valve external hardware shall be Type 316 stainless steel. No internal metallic components shall be exposed to the service fluid.
 - d. No factory or field coatings shall be applied to the valves.
 5. All valves shall have a non-shock service pressure rating of not less than 120 psig at 70 degrees F
 6. All valves shall be given hydrostatic and pressure and leakage tests at the factory. Provide certified copy of test results.
 7. Valves shall be the standard, catalogued products of the following manufacturers:
 - a. Chemtrol
 - b. Asahi/America
 - c. Spears Manufacturing
 - d. Plast-O-Matic
 - e. Hayward
- B. Ball Valves
1. Ball valves shall be the double-union type, unless otherwise specified, with full-port opening.
 2. Provide quarter-turn manual valve operator and valve seat adjustability.
 3. Plastic valves in sodium hypochlorite service shall have the ball drilled to permit venting of pressure and gas from the confined ball cavity, when the valve is closed. The drilling shall vent to the upstream end of the valve. The drilling shall be 1/8-in and de-burred.
 4. Ball valves shall be by Chemtrol, Asahi/America, or Spears Manufacturing.
- C. Electric Operators
1. Electric operators for plastic valves 2-in diameter and less shall be 115Volt, single phase, 60 Hz, reversing motor with integral thermal overload protection with automatic reset, 100 percent duty cycle, 2 single pole double throw open and close limit switches, deswitchable manual override, mechanical visual position indicator, permanently lubricated gear train, stainless steel output shaft, and contacts for remote open/close status. Enclosure shall be rated NEMA 4X.
- D. Ball Check Valves
1. Ball check valves shall be double-union style with socket ends, with solid and completely spherical ball and capable of either horizontal or vertical (flowing up) mounting.
- E. Straight Globe Valves
- F. Pressure Relief Valves

1. Pressure relief valves shall have a socket end as required. Unless otherwise specified, pressure relief valves shall be spring-oriented type top adjusting screw to increase or decrease relief pressure setting between 0-100 psi. Internal spring shall be PVDF coated steel and completely isolated from the system to prevent corrosion.

G. Degassing Vent/Valves for Sodium Hypochlorite Service

2.09 SOLENOID VALVES

- A. Solenoid valves shall be packless piston type direct acting for sizes less than 1-in and internal pilot operated for sizes 1-in and larger, 2-way or 3-way, valves and shall be ASCO Red Hat or similar by Atkomatic Valve Co; or equal.
- B. Valves on seal water lines to unloading pumps shall be of the normally closed type and shall be energized to open due to intermittent pump operation. All other seal water valves shall be normally open type and shall be energized to close. All other valves shall be normally closed type and shall be energized to open.
- C. Valves shall have forged brass bodies, NPT end connections of the connected piping Type 304 stainless steel internal parts, and Buna-N or Ethylene Propylene valve seats. Valves shall have a minimum 150 psig safe working pressure and zero minimum operating pressure differential. Connections shall be threaded.
 1. Except as otherwise specified herein, valves shall be as noted in PART 1.
- D. Solenoid valves on bypass piping shall be installed whether shown or not.
- E. Note that solenoid valves may be shown on Electrical and/or Mechanical Drawings, or may only be specified. Solenoid valves on air supply lines are to be supplied with the mechanical process equipment they are associated with and are specified under the individual mechanical process equipment specifications included in Division 11.

2.10 HOSE END VALVES

- A. Hose end valves shall be ball valves by Fairbanks; Jenkins; or equal. Furnish cap and chain. Furnish size as shown on the Drawings.

2.11 AIR AND/OR AIR/VACUUM VALVES - GENERAL AND SEWAGE USE

- A. This general section applies to all air release, air/vacuum, hydraulically operated air/vacuum valves, vacuum relief, combination air and air/vacuum or vacuum relief or similar valves.
- B. Valves shall be supplied with shutoff gate or ball valves with operator handle or lever removed. Valves shall be properly vented and piped to drain.
- C. Attention is directed to the requirement that the valve's pressure rating be at least equal to the attached pipe's rating.
- D. Valves shall be proper model by ARI, GA Industries, Val-Matic; or APCO.
- E. For service on sewage, sludge (of any type) and non-screened water, the valves shall be of the special sewage type, performing similar functions for specific type of valve as noted for water.

1. The valves shall have Type 316 stainless steel trim and float mechanism, with an adjustable Buna-N viton seat and be supplied with backwash accessories. ARI valves may be constructed of corrosion resistant composite.
2. A valved outlet with hose connections for flushing water connection (where flushing accessories are required) shall be provided within a distance that hoses, supplied with the valve, may reach. Proper cross connection prevention shall be provided.

F. Air Release Valves

1. Air release valves shall be installed to release any small accumulations of air which may collect while pipe is in operation and under pressure.
2. The small orifice assembly air release valve shall automatically release air accumulations from the pipe while under positive pressure. When the valve body fills with air, the float ball shall fall to open the small orifice and exhaust the air to atmosphere. When the air has been exhausted, the float ball shall be buoyed up and tightly close the small orifice.
3. The small orifice assembly shall be furnished with cast iron body and cover (ASTM A126-B), or corrosion resistant composite for ARI valves. The float ball shall be constructed of stainless steel and be attached to a stainless steel lever mechanism. A resilient, Buna-N seat shall be attached to the lever mechanism for drop-tight closure.
4. Separate air release valves shall be manufactured by ARI; APCO; Val-Matic; GA Industries; or Crispin.

G. Air/Vacuum Valves (Normal Operation)

1. The large orifice assembly air and vacuum valve shall automatically exhaust air from a pipeline during the initial filling of the pipeline. The large orifice assembly shall not blow shut while exhausting air, even while venting air at sonic velocity. When all air has been exhausted from the pipeline, the large orifice float ball shall be buoyed up to seat tightly against a resilient seat ring. The large orifice float ball shall remain tightly closed while the pipeline is under positive pressure. Should the pipeline pressure fall below atmospheric pressure (such as during draining or a line break), the large orifice float ball shall automatically fall away from the seat ring and permit air to enter the pipeline.
2. The large orifice assembly shall be furnished with cast iron body and cover (ASTM A126-B), or corrosion resistant composite for ARI valves. A resilient, Buna-N seat ring shall be affixed to the valve cover. The float ball shall be constructed of stainless steel with a minimum pressure rating of 1,000 psi. The float ball shall be free floating within the valve body; guide stems, linkages or levers attached to the float are not acceptable.
3. Unit shall be manufactured by ARI, GA Industries; APCO; or Val-Matic.

H. Combination Air and Air/Vacuum or Vacuum Relief Valves

1. Units shall be a small orifice (air release) valve mounted on a large orifice air/vacuum valve of the proper type and size as noted on the Drawings or as required by equipment manufacturers. Individual valves shall be as specified previously.

2. The small orifice valve shall be piped to the body of the large orifice valve by non-corrosive piping equal in size to the small orifice inlet connection. An isolating stop valve (with operator removed) shall be furnished between the small and large orifice valves.
3. One-piece units performing all functions may be utilized, as acceptable to the Engineer. Component valves shall be as previously specified and be by one manufacturer.

2.12 SURFACE PREPARATION AND SHOP COATINGS

- A. Notwithstanding any of these specified requirements, all coatings and lubricants in contact with potable water shall be certified as acceptable for use with that fluid.
- B. If not specified herein, coatings shall comply with the requirements of Section 09901. In case of a conflict, the requirements of this Section govern.
- C. If the manufacturer's requirement is not to require finished coating on any interior surfaces, then manufacturer shall so state and no interior finish coating will be required, if acceptable to the Engineer.
- D. The exterior surface of various parts of valves, operators, floor-stands and miscellaneous piping shall be thoroughly cleaned of all scale, dirt, grease or other foreign matter and thereafter one shop coat of an approved rust-inhibitive primer shall be applied in accordance with the instructions of the paint manufacturer. Primer shall be compatible with the finish coat provided.
- E. Unless otherwise noted, interior ferrous surfaces of all valves shall be given a shop finish of an asphalt varnish conforming to AWWA C509, (except mounting faces/surfaces) or epoxy AWWA C550 with a minimum thickness of 4 mil.
- F. Ferrous surfaces obviously not to be painted shall be given a shop coat of grease or other suitable rust-resistant coating. Mounting surfaces shall be especially coated with a rust preventative.
- G. Special care shall be taken to protect uncoated items and plastic items, especially from environmental damage.

2.13 FACTORY INSPECTION, TESTING AND CORRECTION OF DEFICIENCIES

- A. Factory inspection, testing and correction of deficiencies shall be done in accordance with the referenced standards and as noted herein.
- B. See Division 1 for additional requirements. Also refer to PART 1, especially for required submission of test data to the Engineer.
- C. In addition to all tests required by the referenced standards, the following shall also be factory tested:
 1. Pressure regulating valves shall be factory tested at the specified pressures and flows.

PART 3 EXECUTION

3.01 INSTALLATION - GENERAL

- A. All valves and appurtenances shall be installed per the manufacturer's instructions in the locations shown, true to alignment and rigidly supported. Any damage to the above items shall be repaired to the satisfaction of the Engineer before they are installed.
- B. Install all brackets, extension rods, guides, the various types of operators and appurtenances as shown on the Drawings, or otherwise required. Before setting these items, check all Drawings and figures, which have a direct bearing on their location. The Contractor shall be responsible for the proper location of valves and appurtenances during the construction of the work.
- C. All materials shall be carefully inspected for defects in construction and materials. All debris and foreign material shall be cleaned out of openings, etc. All valve flange covers shall remain in place until connected piping is in place. All operating mechanisms shall be operated to check their proper functioning and all nuts and bolts checked for tightness. Valves and other equipment, which do not operate easily, or are otherwise defective, shall be repaired or replaced at no additional cost to the Owner.
- D. Where installation is covered by a referenced standard, installation shall be in accordance with that standard, except as herein modified, and the Contractor shall certify such. Also note additional requirements in other parts of this Section.
- E. Unless otherwise noted, joints for valves and appurtenances shall be made up utilizing the same procedures as specified under the applicable type connecting pipe joint and all valves and other items shall be installed in the proper position as recommended by the manufacturer. Contractor shall be responsible for verifying manufacturers' torquing requirements for all valves.

3.02 INSTALLATION OF MANUAL OPERATIONAL DEVICES

- A. Unless otherwise noted, all operational devices shall be installed with the units of the factory, as shown on the Drawings or as acceptable to the Engineer to allow accessibility to operate and maintain the item and to prevent interference with other piping, valves and appurtenances.
- B. For manually operated valves 3-in in diameter and smaller, valve operators and indicators shall be rotated to display toward normal operation locations.
- C. Floor boxes, valve boxes, extension stems and low floor stands shall be installed vertically centered over the operating nut, with couplings as required and the elevation of the box top shall be adjusted to conform with the elevation of the finished floor surface or grade at the completion of the Contract. Boxes and stem guides shall be adequately supported during concrete pouring to maintain vertical alignment.

3.03 INSPECTION, TESTING AND CORRECTION OF DEFICIENCIES

- A. See also Division 1 and Section 15120. Take care not to over pressure valves or appurtenances during pipe testing. If any unit proves to be defective, it shall be replaced or repaired to the satisfaction of the Engineer.

- B. No testing shall be performed until the manufacturer's service engineer has provided written certification that the following installed equipment has been examined and found to be in complete accordance with the manufacturer's requirements:
 - 1. All motorized and air actuated valves.
 - 2. All pressure regulating valves.
- C. Functional Test: Prior to plant startup, all items shall be inspected for proper alignment, quiet operation, proper connection and satisfactory performance. All motorized units shall be operated through 20 complete cycles, without vibration, jamming, leakage, or overheating and perform the specified function. All manual actuators shall be operated through ten complete cycles.
- D. The various pipelines in which the valves and appurtenances are to be installed are specified to be field tested. During these tests any defective valve or appurtenance shall be adjusted, removed and replaced, or otherwise made acceptable to the Engineer.
- E. Various regulating valves, strainers, or other appurtenances shall be tested to demonstrate their conformance with the specified operational capabilities and any deficiencies shall be corrected or the device replaced or otherwise made acceptable to the Engineer.

3.04 CLEANING

- A. All items (including valve interiors) shall be cleaned prior to installation, testing and final acceptance.

END OF SECTION

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SECTION 15120
PROCESS MECHANICAL PIPING SPECIALTIES

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required and install complete test, and make ready for operation all piping specialties required by the work of this Contract. Specific piping materials, systems and related installation and testing requirements shall be coordinated with the related sections in Divisions 2, 13 and 15. The items shall include the following:

1. Unions
2. Flanged Joints
3. Dielectric Connectors
4. Plugs and Caps
5. Miscellaneous Adaptors
6. Vents and Drains
7. Shock Absorbers (Water Hammer Arrestor)
8. Line Strainers
9. Service Clamps
10. Cleanouts
11. Quick Connect Couplings
12. Mechanical Sleeve Seals
13. Flexible Connectors
 - a. Sleeve Couplings
 - b. Split or Grooved Couplings
 - c. Flange Adaptors
 - d. Pump and Equipment Flexible Connectors
 - e. Flexible Connectors
 - f. Transition Couplings
14. Expansion Joints
 - a. Single- and Multiple-Arch Type
 - b. Bellows Style
 - c. Flexible Metal Hose
15. Harnessing and Restraints
16. Pressure Gauges

17. Diaphragm Seals for Gauges
18. Thermometers
19. Rotameters and Flow Indicators
20. Spray Nozzle
21. Wash Hose Stations
22. Appurtenances and Miscellaneous Items
23. Color Coding and Labeling

1.02 RELATED WORK

- A. Pipeline color coding and labeling is included in Section 09902
- B. Piping materials and systems are included in other Sections of Division 15.
- C. Specialties and apparatus furnished with equipment and systems are included in individual Sections in Division 11.
- D. Valves are included in Section 15100.
- E. Pipe supports are included in Section 15140.
- F. Pipe insulation is included in Section 15250.

1.03 SUBMITTALS

- A. Submit, in accordance with Section 01300, general submittals for piping, piping systems and pipeline appurtenances are listed below. It is not intended that all submittals listed below be provided for all piping materials and systems. Refer to individual System or Piping Sections for specific submittals.
- B. Shop Drawings and Product Data
 1. Piping layouts with specialties.
 2. Location of pipe hangers and supports.
 3. Location and type of backup block or device to prevent joint separation.
 4. Large scale details of wall penetrations and fabricated fittings.
 5. Catalog cuts of specialties, joints, couplings, harnesses, expansion joints, gaskets, fasteners and other accessories.
 6. Catalog cuts of all pipeline appurtenances specified herein.

7. Brochures and technical data on coatings and linings and proposed method for application and repair.

C. Samples

D. Design Data

E. Certificates

1. Copies of certification for all welders performing work in accordance with ANSI B31.1.

F. Manufacturers Installation (or application) instructions.

G. Statement of Qualifications

H. Manufacturers Field Report

I. Project Record Document

J. Operation and Maintenance Data in accordance with Section 01730.

K. Warranties

1.04 REFERENCE STANDARDS

A. ASTM International

1. ASTM A36 - Standard Specification for Carbon Structural Steel.
2. ASTM A126 - Standard Specification for Gray Iron Casting for Valves, Flanges and Pipe Fittings.
3. ASTM A183 - Standard Specification for Carbon Steel Track Bolts and Nuts.
4. ASTM A278 - Standard Specification for Gray Iron Castings for Pressure-Containing Parts for Temperatures up to 650 Degrees F.
5. ASTM A307 - Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
6. ASTM A325 - Standard Specification for Strength Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength.
7. ASTM A536 - Standard Specification for Ductile Iron Castings
8. ASTM A575 - Standard Specification for Steel Bars, Carbon, Merchant Quality, M-Grades.
9. ASTM B62 - Standard Specification for Composition Bronze or Ounce Metal Castings.
10. ASTM B88 - Standard Specification for Seamless Copper Water Tube.

- B. American National Standards Institute (ANSI)
 - 1. ANSI A13.1 - Scheme for the Identification of Piping Systems.
 - 2. ANSI B1.1 - Unified Inch Screw Threads (UN and UNR Thread Form)
 - 3. ANSI B18.2 - Square and Hex Bolts and Screws Inch Series Including Hex Cap Screws and Lag Screws.
 - 4. ANSI B31 - Code for Pressure Piping.
 - 5. ANSI B31.1 - Power Piping
- C. American Society of Mechanical Engineers (ASME)
 - 1. ASME B2.1 - Specifications, Dimensions, Gauging for Taper and Straight Pipe Threads (except dry seals).
 - 2. ASME B16.1 - Cast Iron Pipe Flanges and Flanged Fittings.
 - 3. ASME B16.5 - Pipe Flanges and Flange Fittings
- D. American Welding Society (AWS)
 - 1. AWS B3.0 - Welding Procedure and Performance Qualifications
- E. American Water Works Association (AWWA)
 - 1. AWWA C110 - Ductile-Iron and Gray-Iron Fittings, 3-in Through 48-in (75mm Through 1200mm), for Water and Other Liquids.
 - 2. AWWA C111 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
 - 3. AWWA C219 - Bolted Sleeve-Type Couplings for Plain-End Pipe
 - 4. AWWA C606 - Grooved and Shouldered Joints.
 - 5. AWWA Manual M11 - Steel Pipe - A Guide for Design and Installation.
- F. Plumbing and Drainage Institute (PDI)
 - 1. WH 201 - Water Hammer Arrestors
- G. Underwriters Laboratories (UL)
- H. Factory Mutual (FM)
- I. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

- A. All materials shall be new and unused.
- B. Install piping to meet requirements of local codes.
- C. Provide manufacturer's certification that materials meet or exceed minimum requirements as specified.
- D. Coordinate dimensions and drilling of flanges with flanges for valves, pumps and other equipment to be installed in piping systems. Bolt holes in flanges to straddle vertical centerline.
- E. Reject materials contaminated with gasoline, lubricating oil, liquid or gaseous fuel, aromatic compounds, paint solvent, paint thinner and acid solder.
- F. Pipe-joint compound, for pipe carrying flammable or toxic gas, must bear approval of UL or FM.
- G. Unless otherwise specified, pressures referred to in all Piping Sections are expressed in pounds per square inch, gauge above atmospheric pressure, psig and all temperature are expressed in degrees Fahrenheit (F).

1.06 DELIVERY, STORAGE AND HANDLING

- A. During loading, transportation and unloading, take care to prevent damage to pipes and coating. Carefully load and unload each pipe under control at all times. Place skids or blocks under each pipe in the shop and securely wedge pipe during transportation to ensure no injury to pipe and lining. Cover or cap all pipe ends while pipe is in storage, until it is made a part of the work.

PART 2 PRODUCTS

2.01 MATERIALS AND EQUIPMENT

- A. Specific piping materials and appurtenances are specified in the respective Piping or System Sections. The use of a manufacturer's name and/or model number is for the purpose of establishing the standard of quality and general configuration desired.
- B. Equipment shall be of the size shown on the Drawings or as noted and as far as possible equipment of the same type shall be identical and from one manufacturer.
- C. Equipment shall have the name of the maker, nominal size, flow directional arrows (if applicable), working pressure for which they are designed and standard referenced specifications. Equipment titles shall be marked per Section 09902.
- D. Unless otherwise noted, items shall have a minimum working pressure of 150 psi or be of the same working pressure as the pipe they connect to, whichever is higher and suitable for the pressures noted where they are installed.

2.02 UNIONS

- A. Unions shall be brass or bronze unions for joining nonferrous pipe; malleable brass or bronze-seated iron or steel unions for joining ferrous pipe; PVC unions for joining PVC pipe; CPVC unions for joining CPVC pipe.

2.03 FLANGED JOINTS

- A. Flanged Joints. Bolt and nuts, Grade B, ASTM A307 or Type 304 stainless steel, bolt number and size same as flange standard; studs - same quality as machine bolts; 1/16-in thick rubber gaskets with cloth insertions; rust-resistant coatings.

2.04 DIELECTRIC CONNECTORS

- A. Dielectric pipe fittings/insulators and unions shall be used to prevent galvanic action wherever valves or piping of dissimilar metals connect. This shall be particularly the case for copper, brass and bronze piping connecting to cast iron or steel piping systems.
- B. Dielectric unions shall be used for 2-in and smaller connections. Steel union nuts shall meet ASTM A575 requirements. The steel or ductile iron connection end shall have a steel body and shall have accurately machined taper tapped pipe threads in accordance with ASME B2.1. The copper connection end shall be a copper solder joint that meets requirements of ASTM B88. Dielectric unions shall be rated for at least 250 psi at 210 degrees F.
- C. Dielectric flange unions shall be used for connections 2-1/2-in and larger. Cast iron flanges shall meet ASTM A126; the copper solder end shall meet ASTM B62 and the pipe thread shall meet ASME B2.1. Dielectric flange unions shall be rated for at least 175 psi at 210 degrees F.
- D. Dielectric unions and flange unions shall be as manufactured by Epco Inc., Cleveland, OH or equal.
- E. Flange insulating kits shall be as acceptable to the Engineer, as manufactured by PSI or equal.
- F. Insulated sleeve couplings and flange adaptors shall be similar to those units as specified elsewhere.

2.05 PLUGS AND CAPS

- A. Provide standard plug or cap as required for testing; plugs, caps suitable for permanent service.
- B. Plug or cap or otherwise cover all piping work in progress.

2.06 MISCELLANEOUS ADAPTORS

- A. Between different types of pipe and/or fittings special adapters may be required to provide proper connection. Some of these may be indicated on the Drawings or specified with individual types of pipe or equipment. However, it is the Contractor's responsibility to ensure proper connection between various types of pipe, to structures and between pipe and valves, gates, fittings and other appurtenances. Provide all adapters as required, whether specifically noted or not.

- B. As required, these adapters shall be suitable for direct bury, with proper dielectric insulation and as a minimum, if metallic (not stainless steel or galvanized), with two coats of Coal Tar Epoxy.

2.07 VENTS AND DRAINS

- A. 1/2-in vents shall be provided at the high point in each system. Vent connections may be tapped, provided the tap will accept three full threads on the bronze nipple.
- B. 1-1/2-in drains shall be provided to permit drainage of each system located on the invert of the blind flange; provide hose-end valve.

2.08 SHOCK ABSORBERS (WATER HAMMER ARRESTORS)

- A. Shock absorbers shall be supplied on the non-potable and potable water piping. The shock absorbers shall be Model 1485-1 as manufactured by Josam Manufacturing Company, Michigan City, IN; similar model by J.R. Smith or Zurn Industries; or equal.
- B. Arrestors shall be sized in accordance with PDI WH 201, for all hot and cold water systems.
- C. Placement shall be in accordance with PDI WH 201 with a minimum of one shock absorber at each quick acting valve, lever operated valve, self closing valve and self closing valve/faucet; or a minimum of one for each battery of these fixtures. The water hammer arrestors shall be accessible for maintenance.

2.09 LINE STRAINERS

A. "Y" Type Strainers

1. Manual strainers furnished for pipe diameters smaller than 2-in shall be "Y" type, capable of removing solids 0.01-in in diameter and larger. The strainer body shall be of semi-steel construction for steel pipe and brass or bronze for copper pipe and shall conform to the latest revision of ASTM A278, Class 30. Strainer elements, including woven wire mesh, shall be constructed of stainless steel.
2. The design of the strainer body shall be such that the cleanout plug and screen may be easily removed to permit inspection and cleaning without disassembly of the inlet and outlet piping. End connections shall be ANSI screwed pipe threads.
3. Sufficient spare screen shall be furnished for replacement of all "Y" type units at least once. The strainers shall be designed for a maximum operating pressure of 150 psig. They shall be as manufactured by GA Industries Inc., Pittsburg, PA or equal.

B. Manual Basket Strainer

1. Manual basket strainers shall be furnished for pipe diameters 2-in in diameter and larger as shown on the Drawings. The mesh size shall be 150 microns (100 mesh) unless otherwise specified herein or on the Drawings.
2. The strainer body shall be equivalent to Schedule 80 PVC pipe. The strainer elements, including woven wire screen, shall be constructed of Type 304 stainless steel. The bodies of the strainers shall be of heavy-duty construction, with an easily removable gasketed

cover. The body shall be supplied with female NPT threaded connections. The design of the basket strainer body shall be such that the bolted lid and basket may be easily removed for inspection and cleaning without disassembly of the inlet and outlet piping.

3. A trap with a blow-off port shall be provided for removing any material that may settle at the bottom. The strainers shall be designed for a maximum operating pressure of 150 psig. Strainer shall be a Simplex Basket Strainer as manufactured by Hayward, or equivalent design and materials by Spears Manufacturing Company or GA Industries Inc, or approved equal.
4. Proper blow-off piping with valve shall be supplied and run to nearest drain.

C. Rotating Screen Strainer

1. In-line rotating dual screen strainers shall be furnished for pipe diameters 2-in in diameter and larger, as shown on the Drawings. The strainer shall employ two handwheel-equipped rotating screens and rigid scraper bars to remove solids from the surface of the screens when the handwheels are rotated. The strainer shall be equipped with a solids-collecting sump. Cleaning of the strainer shall be accomplished by opening a valve on the sump flush connection (while operating under positive pressure) and rotating the handwheels several times.
2. The strainer body shall be of cast iron construction and be equipped with flanges to match process piping. The strainer elements, including the perforated metal screen, shall be constructed of Type 304 stainless steel. Screen perforations shall be 3/32-inch staggered, with 33% open area.
3. The strainer shall allow for external scraper adjustment. Strainers that require disassembly for cleaning are not acceptable.
4. The strainers shall be designed for a maximum operating pressure of 150 psig, and shall be Type DH as manufactured by Hellan® Strainer or approved equal.
5. Strainer shall be equipped with a solids flush outlet and ball valve. Solids flush shall be run to the nearest drain as shown on Drawings.

2.10 SERVICE CLAMPS

- A. Service clamps for outlet sizes up to 2-in shall have malleable or ductile iron bodies which extend at least 160 degrees around the circumference of the pipe and shall have neoprene gaskets cemented to the saddle body. Bodies shall be tapped for IPS. Clamps shall be of the double strap design. Service clamps shall be Style 91 by Dresser Industries, Inc.; Smith Blair; Mueller or equal.
- B. Service clamps for outlet sizes 4-in through 12-in where the outlet size is not greater than half the size of the main pipe shall have ductile iron bodies and a neoprene circular cross section O-ring gasket confined within the body. Outlet shall be AWWA C110 flange or AWWA C111 mechanical joint as required for the application. Straps shall be alloy steel, minimum 1/4-in by 1-1/2-in in cross section and fabricated with 3/4-in threaded ends. Service clamps shall be Fig. A-10920 or A-30920 by American Cast Iron Pipe Company or equal.

2.11 CLEANOUTS

- A. Interior flush floor cleanouts shall consist of a coated cast iron ferrule, a tapered threaded bronze cleanout plug, adjustable housing and a scoriated round cast iron tractor cover with bronze top. Interior flush floor cleanouts shall be Type No. 56056 by Josam Manufacturing Co., Michigan City, IN, similar models by Tyler, or equal.
- B. Exterior cleanouts shall consist of a coated cast iron ferrule with cut-off sections, a tapered threaded bronze cleanout plug, Josam 58486 or equal, with a heavy round coated cast iron access frame with anchor flanges and a gasketed cover, Josam Type No. 58680, similar models by Tyler or equal. Exterior cleanouts shall be installed as noted on the Drawings.
- C. Cleanouts shall be located where shown on the Drawings.
- D. Cleanout connections to 6-in cast iron bell and spigot soil pipe and cleanout connections to 6-in ductile iron bell and spigot pipe shall be caulked.

2.12 QUICK CONNECT COUPLINGS

- A. Couplings shall be of the cam and groove type consisting of a male adapter conforming to MIL-C-27487. Male adapters shall be designed to receive a female coupler without requiring threading, bolting, or tools. Connections shall remain tight and leak proof under pressures up to 100 psig. Each adapter shall be furnished with a dust cap complete with a 18-in long security chain of corrosion resistant material. Couplings shall be by Civacon, a Division of Dover Corporation; Ever-tite or equal. Units shall be "drip proof", providing totally dry connections and dis-connections.
- B. Adapters shall be furnished in accordance with the Drawings, or as required by the installation.

2.13 MECHANICAL SLEEVE SEALS

- A. Mechanical sleeve seals shall be used to secure and seal the annular space around all new sleeved and core-drilled wall penetrations.
- B. A single seal shall be provided for all sleeve and cores in walls up to 14-in thick; dual sleeves shall be provided in larger walls.
- C. Galvanized steel wall sleeves and concrete core diameter shall be sized sufficiently larger to accommodate the modular elements, per the manufacturer's recommendations.
- D. Bolts and hardware shall be carbon steel, zinc-plated. Pressure plates shall be corrosion-resistant acetal resin.
- E. Mechanical sleeve seals shall consist of modular bolted, synthetic rubber sealing elements, Link Seal by Thunderline Corp. or equal.

2.14 FLEXIBLE CONNECTORS

A. Sleeve Couplings

1. Provide plain end type ends to be joined by sleeve couplings as stipulated in AWWA C219.
 - a. Join welds on ends by couplings without pipe stops. Grind flush to permit slipping coupling in at least one direction to clear pipe joint.
 - b. Outside diameter and out-of-round tolerances shall be within limits specified by coupling manufacturer.
 - c. Provide lugs in accordance with ASTM A36.
 - d. Provide hardened steel washers in accordance with ASTM A325.
 - e. Plastic plugs shall be fitted in coupling to protect bolt holes.
 - f. Nuts and bolts
 - 1) Provide bolts and bolt-studs in accordance with ASTM A307 and ANSI B1.1 with hexagonal or square heads, coarse thread fit, threaded full length with ends chamfered or rounded.
 - 2) Project ends 1/4-in beyond surface of nuts.
 - 3) Hexagonal nuts with dimensions in accordance with ANSI B18.2 and coarse threads in accordance with ANSI B1.1.
2. Middle ring of each mechanical coupling shall have a thickness at least equal to that specified for size of pipe on which coupling is to be used and shall not be less than 10-in long for pipe 30-in and larger and not less than 7-in long for pipe under 30-in in diameter.
 - a. Omit pipe stop from inner surface of middle rings of couplings whenever necessary to permit removal of valves, flowmeters and other installed equipment.
 - b. Provide pipe stops in other couplings.
3. Clean and shop prime with manufacturer's standard rust inhibitive primer.
4. Furnish gaskets of a composition suitable for exposure to the fluid service.
5. Where shown on the Drawings, anchor sleeve-coupled joints with harness bolts. Weld harness lugs to steel pipe.
 - a. Joint harness bolts shall be of sufficient length, with harness lugs placed so that coupling can be slipped at least in one direction to clear joint. Provide harnesses of sufficient number and strength to withstand test pressure as recommended in AWWA M-11.
 - b. Each harness shall have a minimum of two 5/8-in diameter bolts.
6. Unless otherwise specified with the individual type of pipe, sleeve couplings (mechanical couplings) shall be Victaulic Depend-O-Lok E x E (unrestrained) or F x F (self-restrained); Smith Blair (part of Sensus) Style 411; Dresser Style 38, similar models by Baker or equal, with the pipe stop removed.
7. Similar insulation type couplings shall be provided at the face of buildings, between different type metals or where otherwise noted.
8. In addition to those locations noted on the Drawings, sleeve couplings shall be provided on all piping where it connects with a structure or buried directly under a structure at the structure's expansion joints. Special treatment will be required where pipe is encased in

concrete, utilizing minimum 3-in thick styrofoam placed perpendicular to the horizontal centerline of the coupling.

B. Split or Grooved Couplings

1. Split couplings shall be cast in two or more parts. When secured together with ASTM A183 bolts and nuts, couplings shall engage grooved or shouldered pipe ends and encase an elastomeric gasket to create a pipe seal. Gasket material shall be as recommended by the manufacturer for the service required.
2. Split couplings shall be as manufactured by Victaulic Company of America or equal. Numbers below refer to Victaulic Co. items, for reference only.
3. Unless otherwise specified with the individual type of pipe:
 - a. Flexible split ring couplings shall be:
 - 1) grooved ends - Style 77 (for steel/stainless steel) or Style 31 (for grooved ductile iron)
 - 2) shouldered ends – Victaulic Style 44 or Fluid Master
 - 3) fixed ends – Victaulic Depend-O-Lok, F x F (fixed by fixed)
 - b. Rigid split ring couplings shall be:
 - 1) grooved ends - rigid groove with Style 31 couplings on ductile iron 36-in and smaller diameter with sufficient wall thickness per AWWA C606, or manufacturer's recommendation, or standard groove with Style 07 Zero-Flex coupling on manufactured steel or IPS pipe.
 - 2) shouldered ends – Style 44 coupling on ductile iron over 36-in diameter or without sufficient wall thickness per AWWA C606 or on manufactured steel pipe or thin wall stainless steel pipe. Field welding of shoulders of ductile iron pipe is specifically prohibited.
4. Ductile iron pipe for use with split-type coupling joints shall have radius grooved ends conforming to AWWA C606. Pipe shall have grooved ends to provide either a rigid joint or flexible joint as shown on the Drawings and as specified herein. Flexible joint grooving shall permit expansion and contraction, and angular deflection. Rigid joint grooving shall allow no angular or linear movement. Minimum pipe wall thickness for grooved pipe shall be the following class:

| Size | Class |
|-----------|-------|
| 4 thru 16 | 53 |
| 18 | 54 |
| 20 | 55 |
| 24 | 56 |

5. Grooved couplings for steel and stainless steel piping shall have roll grooving, machine-grooving, or ring collars fully welded to the pipe or fitting.
6. Rigid split couplings may be substituted for flanges as noted on the Drawings and in the individual pipe requirements.
7. Certain minimum thickness of pipe walls are required by AWWA C606 and coupling manufacturers for use of various type split couplings with certain pipes. Utilize at least

those minimum wall thicknesses required (unless a greater thickness is specified or required in the individual pipe specifications) with split couplings.

8. If minimum thicknesses are not utilized with grooving, then a shouldered end treatment with couplings as noted shall be utilized.

C. Flanged Adaptors

1. Flanged adaptor connections for grooved or shouldered end pipe compatible with split couplings at fittings, valves and equipment shall be VIC-Flange Style 341 (ductile iron pipe and VIC-Flange Style 741/743 (for steel and stainless steel pipe) by the Victaulic Company of America, equal by Depend-O-Lok F x F FAC by Victaulic Depend-O-Lok Inc. or equal.
2. Flanged adaptor connections for plain end pipe at fittings, valves and equipment shall be Dresser Style 127 or 128, equal by Smith-Blair (part of Sensus); Depend-O-Lok F x E FAC by Victaulic Depend-O-Lok, Inc. or equal.

D. Pump and Equipment Flexible Connectors

1. The flexible connectors shall be expansion/vibration joints of the single arch type of butyl rubber construction with carcass of high grade woven cotton or suitable synthetic fiber and individual solid steel ring reinforcement. Soft rubber fillers shall be integrally cured into the arches to provide a smooth flow path to prevent settling of material into the arch. Joints shall be constructed to pipeline size and to meet working pressures and corrosive conditions similar to the line where installed. Joints shall have full faced fabric reinforced butyl flanges integral with the body.
2. Split steel or ductile iron back-up rings shall be provided to ensure a good joint. Rings shall be designed for mating with ANSI Standard minimum 150 lb. flanges. All joints shall be finish coated with Hypalon or equal paint.
3. Expansion/vibration joints shall be furnished with control (harness) units. Harness units shall consist of minimum two drilled plates, stretcher bolts, and rubber washers backed by metal washers. The stretcher bolts shall prevent over-elongation of the joint. Extra nuts shall be provided on the stretcher bolts on the inside of the plate to prevent overcompression. All nuts, bolts and plates shall be galvanized.
4. The manufacturer of the expansion joints shall be a member of the Rubber Expansion Joint Division of the Fluid Sealing Association. Expansion joints shall be Style 1025 filled arch by General Rubber Corp., Carlstadt NJ or similar products of Mercer Rubber; Goodall Rubber; Garlock; Red Valve Co., Inc.; Proco Products Inc., Stockton, CA or equal.
5. In addition to other locations shown on the Drawings, expansion joints shall be utilized in all exposed piping, within 1-ft of a building expansion joint, and on the suction and discharge side of all positive displacement pumps, compressors and rotating machinery, as close to the unit as possible.

E. Flexible Connectors

1. Provide one flexible connector for the seal water connection to each pump stuffing box. Connectors shall be of hose of Buna-N or similar resilient material, with fiber reinforcement, rated minimum 150 psi with bronze or Type 304 stainless steel NPT end fittings and shall be 12-in in length. Connectors shall be for the purpose of isolating pump vibration from the seal water piping.

F. Transition Couplings

1. Provide transition couplings as shown on the Drawings and for connecting pipes of same nominal size but with different outside diameters and materials. Transition couplings shall meet AWWA C219 and be coated inside and outside with fusion bonded epoxy in accordance with AWWA C213. Transition couplings shall be Smith-Blair, Inc.; Romac Industries, Inc.; JCM Industries, Inc.; Power Seal Corp.; Ford Meter Box Co.; Dresser Piping Specialties; or equal.

2.15 EXPANSION JOINTS

A. Expansion Couplings

1. Bolted split sleeve type couplings to allow for thermal expansion and contraction at the pipe joints shall consist of one piece housing, gasket assembly, bolts and nuts, and end rings to hold the coupling in the proper location.
2. Couplings shall be manufactured from ASTM A240 Type 304 or Type 316 stainless steel material for use on stainless steel pipe. Couplings for use on carbon steel or ductile iron pipe shall be manufactured from ASTM A36 material. Gaskets shall be of a composition suitable for exposure to the fluid or air service.
3. Carbon steel couplings shall be coated in accordance with liquid epoxy coating per AWWA C210 or fusion bonded epoxy coating per AWWA C213. Manufacturers standard shop primer will not be accepted as a coating system. Stainless steel couplings shall be passivated after all welding is completed.
4. End rings of the same material as the coupling housing shall be welded to the plain end of the pipe ends that form the joint per the coupling manufacturer's recommendations to hold the coupling in the proper location.
5. The expansion joints shall be designed for the axial movements shown on the Drawings along with the maximum axial force required to compress the joint. The joints shall prevent axial, lateral and rotational movement and vibration from being transmitted to the piping and equipment and shall be suitable for 50 psig operating pressure unless otherwise indicated.
6. Expansion couplings for expansion joints for plain end pipe shall be Depend-O-Lok F x E by Victaulic Depend-O-Lok, equal by Red Valve Company, or equal.

B. Single- and Multiple-Arch Type

1. The expansion joints shall be of the rubber spool type, soft rubber filled with single-, double-, or triple-arch steel reinforced expansion joint, as indicated on the Drawings, suitable for 120 degrees F service, unless otherwise indicated.
2. The rubber used shall be suited for service with wastewater and/or wastewater sludge, including three-ply abrasion resistant liner.
3. Provide galvanized retaining rings to mate with adjacent pipe flanges.
4. The joints shall prevent axial, lateral and rotational movement and vibration from being transmitted to the piping and equipment and shall be suitable for 50 psig operating pressure unless otherwise indicated.
5. Provide guides for each expansion joint.

C. Flexible Metal Hose

1. Flexible metal hose shall be constructed of corrugated inner tubing of tin-bronze or Type 321 stainless steel and shall have an outer shield of wire-braid of either tin-bronze or Type 321 stainless steel.
2. The flexible hose connectors shall have a length not less than five times the nominal pipe diameter.
3. The connectors shall have 150 psi flanged ends in all sizes and shall be suitable for pressure up to 150 psig and temperatures to 400 degrees F.
4. Flexible hose connectors shall be manufactured by Flexonics; Metraflex or equal.

2.16 HARNESSING AND RESTRAINT

- A. Where harnessed couplings or adapters are noted, they shall conform to AWWA Manual M11 except as modified by the Drawings or this Section.
- B. Unless otherwise noted, size and material for tie rods, clamps, plates and hex nuts shall be as shown on the Drawings, or, if not shown on the Drawings, shall be as required in AWWA Manual M11. Manufactured restraining clamp assemblies shall be as manufactured by Stellar Corporation, Columbus, OH, or equal.
- C. Restrained joints (such as welded, locking mechanical joints) shall be of the type specified with the individual type of pipe. If not specified, restrained (locking) mechanical joint pipe shall be of the manufacturer's standard design utilizing a locking device (ring or ears) integrally cast with the pipe.
- D. For up through 18-in diameter ductile iron pipe only, the following may be used as an alternative to other restraint system:
 1. The optional mechanical joint restraints shall be incorporated in the design of a follower gland. The gland shall be manufactured of ductile iron conforming to ASTM A536.

Dimensions of the gland shall be such that it can be used with the standardized mechanical joint bell and tee-head bolts as specified with the pipe.

2. The restraint mechanism shall consist of numerous individually activated gripping surfaces to maximize restraint capability. The gripping surfaces shall be wedges designed to spread the bearing surfaces on the pipe. Twist-off nuts, sized same as tee-head bolts, shall be used to ensure proper actuating of restraining devices. When the nut is sheared off, standard hex nut shall remain.
 3. The mechanical joint restraint device for ductile iron pipe shall have a working pressure of at least 250 psi with a minimum safety factor of 2:1.
 4. The mechanical joint restraint devices shall be of the type listed below or equal.
 5. For Ductile Iron Pipe: EBAA Iron, Inc. Megalug 1100 series for up to 12-in only.
- E. The Contractor shall be responsible for anchorage including restraint as noted elsewhere in Division 15.

2.17 PRESSURE GAUGES

- A. Bosses, connections, or nipples for gauges shall be provided as acceptable to the Engineer. Unbossed tappings shall not be acceptable. Where gauge tappings are not available in the suction or discharge nozzle, the necessary tapping in the adjacent piping shall be made.
- B. In addition to the locations shown on the Drawings, pressure gauges shall be furnished and installed on the upstream and downstream sides of pressure reducing stations and in the suction and discharge nozzle of all pumps, compressors and similar equipment. Additional pressure gauges shall be furnished and installed as specified with individual equipment.
- C. Gauges shall be furnished as part of a complete factory assembly, including gauge, snubber, liquid fill, bar stock ball valve isolation valve and threaded red brass connecting piping.
- D. Unless otherwise noted, gauge rating shall be from 0 to at least 2.5 percent higher than the rating of the pipe it is connected to.
- E. For Liquid Service
 1. Pressure gauges shall have a ABS or FRP case and shall be 4-1/2-in nominal diameter with a full-sized Type 316 stainless steel Bourdon tube and a 300 series stainless steel movement. The gauges shall be liquid filled with glycerin and shall be provided with a filler/breather cap. The socket shall be 1/4-in NPT Type 316 stainless steel with a bottom connection and the dial shall be a white background with black markings. Gauges shall be ANSI Grade A plus or minus one percent of scale and shall have a blow-out back design.
 2. Gauges for the above services shall be liquid filled as manufactured by U.S. Gauge; Ashcroft; Terice; or approved equal.
- F. Gauges shall be furnished from standard ranges of the manufacturer, with dual range (ft. and psi) scales, per the following schedule.

2.18 DIAPHRAGM SEALS FOR GAUGES

- A. Diaphragm seals shall be installed for all pressure gauges and pressure switches not on clean water lines, to protect pressure gauges and pressure switches from contact with the fluid in the pipeline. Gauges shall be furnished as part of a complete factory assembly, including gauge, snubber, diaphragm seal, liquid fill, bar stock isolation valve and threaded red brass interconnecting piping. Furnish also a 1/4-in backflushing connection and ball valve.
- B. Diaphragm seals shall be minimum 2-1/2-in diameter, or as required for the connected pressure gauges. The diaphragm shall be "thread attached" to both piping and pressure switches or gauges. Furnish mineral oil fill between the diaphragm seal and the gauge.
 - 1. Diaphragm seals shall have an upper housing of cadmium plated carbon steel, with the lower housing of Type 316 stainless steel with Type 304 stainless steel bolts. Diaphragms shall be Teflon.
 - 2. Each diaphragm seal shall be connected to its respective piping or equipment with threaded red brass pipe and fittings. Pipe size and diaphragm tap size shall match the size of the gauge tap on the equipment, but shall not be less than 3/4-in, except for connections to plant water piping which shall be minimum 1/2-in. Furnish a ball valve shut-off valve between the pipeline or equipment and the diaphragm seal.
 - 3. Each diaphragm seal shall have a minimum 1/4-in NPT flush connection with ball valve and gauge tap to match the size of the gauge.
 - 4. Furnish pulsation dampeners adequate to prevent pulsation and/or vibration of the gauge indicator under all system operating conditions.
 - 5. Pump gauges shall connect to the diaphragm seal by a flexible Type 304 stainless steel capillary tube. Gauges shall be mounted on a support stand independent of the pump and piping, to minimize vibration of the gauges caused by vibration of the equipment or piping. Mount both the suction and discharge gauges at the same elevation. Furnish supports as specified in Section 15140, or attach gauges to the seal water assembly support (where applicable).
 - 6. Diaphragm seals shall be Type SG by Mansfield and Green; Ashcroft or equal.
- C. Where installed on chlorine lines, or lines leading to chlorine ejectors, seals shall be special chlorine-resistant type. All other materials shall be certified corrosion resistant for seal location and fluid.
- D. Diaphragm seals for chemical piping pressure gauges shall be equal to Series 30 threaded-end (1/2-in to 1-in diameter piping) or Series 40 flange (1-1/2-in to 2-in diameter piping) as manufactured by Red Valve. Body shall be PVC or Type 304 stainless steel with PVC end caps and diaphragms shall be Hypalon.

2.19 THERMOMETERS

- A. Thermometers shall be installed in the locations, and with the temperature ranges shown on the Drawings. Each thermometer shall be installed within a thermowell. The thermowell shall be designed to project sufficiently into the flow stream to assure an accurate thermometer reading.

Thermowells shall be of Type 304 stainless steel, and shall have a bore suitable for a 1/4-in thermometer stem diameter. The process piping connection shall be 1/2-in NPT, except where flanged connections are shown.

- B. Thermometers shall have a 3-in diameter dial case with bottom connection. The case, connection and stem shall be of Type 304 stainless steel and the lens shall be of tempered glass. Thermometers shall have an external calibration reset adjustment and shall be accurate to within one percent of scale.
- C. Thermometers shall be as manufactured by Helicoid, a Division of Bristol-Babcock; Ashcroft, or equal.

2.20 ROTAMETERS AND FLOW INDICATORS

- A. Rotameters for the systems listed below shall be of the glass tube type with Borosilicate glass tubes, Type 302 stainless steel frames with slip-on covers, 10-in detached type aluminum scales graduated in gallons per minute, 10:1 flow range, accuracy of two percent of full scale and vertical screwed end connections. Capacity, size and materials of construction shall be in accordance with the following table. Tube size shall be the same size as the end connections. Pressure drop at rated capacity shall not exceed 32-in of water.

Flow indicators for shaft seal/flushing water systems shall be brass body, glass or plastic tube, stainless steel float, 125 psi pressure rating.

2.21 SPRAY NOZZLES

- A. Nozzles shall be of the size, with feed rates as noted on the Drawings. Nozzles shall be attached to the distribution header, as indicated on the Drawings, via split-eyelet connections. Unless otherwise noted nozzles shall be brass.
- B. Each nozzle shall be furnished with a stainless steel adjustable ball fitting.
- C. The distribution piping to the nozzles shall be sloped for drainage and shall be adequately supported under the access bridge to prevent sagging, while facilitating access for nozzle replacement. Test the system to demonstrate to the Engineer that it is entirely self-draining prior to acceptance.
- D. 10 nozzles shall be provided as spares and shall be suitably boxed and marked for storage.
- E. All nozzles shall be the appropriate model, as manufactured by Spraying Systems Incorporated or equal.

2.22 WASH HOSE STATIONS

- A. Where indicated on the Drawings, stations shall be a 1 1/4 in, single supply, wall mounted hose station complete. Hose nozzles shall be Dixon Valve, Part No. BFN150NST, or equal. The 1-1/4-in hose shall be Hypalon Imperial, Figure No. 800 (yellow) double jacketed complete with expansion ring couplings at each end. The pipe hanger shall be copper plated malleable iron split ring type with malleable iron wall plate to receive 3/8-in diameter threaded rod. The wall anchors for hose rack shall be 5/16-in threaded stainless steel anchors with 5/16-in stainless steel hex bolts. The assembly shall be as provided by Leonard Valve Company, Model No. SW-

75-1572-HDHR-50HDH (1-1/4-IN)-FOG; or similar by F.W. Webb Company (formerly Joseph A. Pink & Son); or equal.

- B. Where indicated on the Drawings, stations shall be a 3/4 in, single supply, wall mounted hose station complete. Hose nozzles shall be Dixon Valve or equal. The 3/4-in hose shall be Hypalon Imperial, Figure No. 800 (yellow) double jacketed complete with expansion ring couplings at each end. The pipe hanger shall be copper plated malleable iron split ring type with malleable iron wall plate to receive 3/8-in diameter threaded rod. The wall anchors for hose rack shall be 5/16-in threaded stainless steel anchors with 5/16-in stainless steel hex bolts. The assembly shall be as provided by Leonard Valve Company; or F.W. Webb Company (formerly Joseph A. Pink & Son); or equal.
- C. Caution Sign for Plant Water Hose Stations
 - 1. Signs shall be aluminum backed and suitable for outdoor application. Signs shall be mounted to the yard hydrants using stainless steel No.16 single jack chain. Signs shall be manufactured by Emedco or equal, and shall say “DO NOT DRINK THE WATER – NO TOMAR EL AGUA”, as shown on the Drawings.

2.23 APPURTENANCES AND MISCELLANEOUS ITEMS

- A. All gaskets, glands, bolts, nuts and other required hardware shall be provided for connection of piping and appurtenances. Bolts and nuts shall be high strength, Type 316 stainless steel if submerged, buried, or subject to splashing and cadmium plated otherwise, with tee-head and hexagon nut. All other hardware shall be of the size, type and number as required and recommended by the piping or appurtenance manufacturer and as specified herein.
- B. All gaskets for flanges shall be full face and suitable for 200 degrees F operating temperature, unless higher temperature required on individual systems and the fluids carried. See also Division 1.
- C. Plugs, caps and similar accessories shall be of the same material as the pipe and of the locking type, unless otherwise noted.
- D. Unions shall be of the same material as the pipe, except for dielectric connections.
- E. Special protective tape shall be fabric reinforced petroleum tape by Denso Inc., Houston, TX or equal.

2.24 COLOR CODING AND LABELING

- A. General
 - 1. Provide a complete color coding system consisting of preprinted labels and banding by Brady; Seton or equal. Field painting shall be specified in Section 09902. Painting and coding shall comply with the requirements of the PIPE COLOR SCHEDULE.

PIEP COLOR SCHEDULE

| Abbr. | Service Fluid | Color | Pipe Marker Legend |
|-------|-------------------|---------------|--------------------|
| TSC | Thickened Scum | Burnt Orange | SCUM |
| SL | Thickened Sludge | Brown | SLUDGE |
| DR | Drain | Black | DRAIN |
| NPW | Non-potable Water | Safety Purple | NPW |

2. Piping system identification shall comply with the requirements of ANSI A13.1.
3. Colors listed are general. Actual colors will be selected based on a comparison to the existing plant color codes, except as otherwise indicated; samples shall be furnished for all pipe paint colors; with chips from existing piping where new service lines are connecting.
4. Banding
 - a. Bands shall be the same color as the pipe.
 - b. Unless special spacing is listed in schedule, apply banding to pipe at connections to equipment, valves, branch fittings, at wall, floor, or ceiling boundaries and at intervals not greater than 36-ft.
5. Labels and directional arrows shall be as specified in Section 09902.

PART 3 EXECUTION

3.01 GENERAL

- A. All dirt, scale, weld splatter, water and other foreign matter shall be removed from the inside and outside of all pipe and sub-assemblies prior to installing.
- B. All pipe joints and connections to equipment shall be made in such a manner as to produce a minimum of strain at the joint.
- C. Test Connections
 1. Provide 1/2-in female NPT test connection equipped with 1/2-in brass plug on all pump suction and discharge lines. Where indicated on the Drawings, test connections should be equipped with bar stock valve and gauge. Provide test connections at all steam traps. The connection shall be located on the discharge side of the trap between the trap and the first valve. It shall consist of a 1/2-in branch connection terminated with a gate valve.
- D. Installation of Expansion Joints and Flexible Connectors
 1. Piping systems shall be aligned prior to installation of expansion fittings. Alignment shall be provided by fitting a rigid pipe spool in place of the expansion joint. Prior to testing of the piping system, the pipe spool shall be replaced with the specified expansion or flexible fitting.
 2. In addition to the locations noted on the Drawings and in PART 2, expansion fittings and anchors shall be located and spaced as specified by the Expansion Joint Manufacturer's

Association. The expansion joints/flexible connectors shall not be installed during times of temperature extreme or in a fully compressed or fully expanded condition.

E. Installation of Sleeve Couplings

1. Unless otherwise required by the manufacturer's instructions, prior to installation of sleeve couplings, the pipe ends shall be cleaned thoroughly for a distance of at least 12-in. Soapy water may be used as a gasket lubricant. A follower and gasket, in that order, shall be slipped over each pipe to a distance of about 6-in from the end, the middle ring shall be placed on the already installed pipe and shall be inserted into the middle ring flair and brought to proper position in relation to the pipe already installed. The gaskets and followers shall then be pressed evenly and firmly into the middle ring flares.
2. After the bolts have been inserted and all nuts have been made up fingertight, diametrically opposite nuts shall be progressively and uniformly tightened all around the joint, preferably by use of a torque wrench of the appropriate size and torque for the bolts.
3. The correct torque as indicated by a torque wrench shall not exceed 75 ft-lb for 5/8-in bolts and 90 ft-lb for 3/4-in bolts.
4. If a wrench other than a torque wrench is used, it should be no longer than 12-in so that when used by the average person the above torque values shall not be exceeded.
5. To prevent sleeve couplings from pulling apart under pressure, a suitable harnessing or flange clamp assembly shall be provided and installed where shown on the Drawings, directed by the Engineer or required elsewhere under Division 15 concerning anchorage.
6. Note the additional locations required for sleeve couplings in PART 2. Also note Contractor's responsibility for locating, providing and installing restraints.

F. Installation of Split Couplings

1. Prior to assembly of split couplings, grooves or shoulders of the pipe as well as other parts shall be thoroughly cleaned. The ends of the pipes and outside of the gaskets shall be moderately coated with manufacturer's recommended lubricant, petroleum jelly, cup grease, soft soap, or graphite paste and the gasket shall be slipped over one pipe end. Lubricant shall be compatible with potable water application. After the other pipe has been brought to the correct position, the gasket shall be centered properly over the pipe ends with the lips against the pipes. The housing sections then shall be placed.
2. Ensure that the joints are fully extended after the rings are in place and prior to tightening the bolts. After the bolts have been inserted, the nuts shall be tightened until the housing sections are firmly in contact, as required by the manufacturer, without excessive bolt tension or strain on the pipe.

G. Installation of Pipeline Appurtenances

1. All pipeline appurtenances shall be installed as required and in accordance with the manufacturer's recommendations, as acceptable to the Engineer.

2. Gauges, meters and similar in-line items shall be isolated from testing pressures in excess of the rated pressure of the assembly.
3. Use Teflon tape on all screwed fittings.

H. Installation of Unions

1. Use unions to allow dismantling of pipe, valves, and equipment.

I. Welding

1. Welding shall be in accordance with ANSI B31 and AWS B3.0.
2. Install welding fittings on all welded lines. Make changes in direction and intersection of lines with welding fittings. Do not miter pipes to form elbows or notch straight runs to form tees, or any similar construction. Do not employ welder who has not been fully qualified in above specified procedure and so certified by approved welding bureau or similar locally recognized testing authority.

J. Installation of Flanged Joints

1. Make flanged joints with bolts; bolt studs with nut on each end; or studs with nuts where one flange is tapped. Use number and size of bolts conforming to same ANSI Standard as flanges. Before flanges pieces are assembled, remove rust resistant coating from machined surfaces, clean gaskets and smooth all burrs and other defects. Make up flanged joints tight, care being taken to prevent undue strain upon valves or other pieces of equipment.

3.02 TESTING

- A. Test all pipelines for water/gas tightness as specified in the Piping or System Sections. Furnish all labor, testing plugs or caps, pressure pumps, pipe connections, gauges and all other equipment required. Testing shall be performed in accordance with one or more of the testing procedures appended to this Section as specified in each Piping or System Section. All testing shall be performed in the presence of the Engineer.
- B. Repair faulty joints or remove defective pipe and fittings and replace as approved by the Engineer. Retest.

3.03 DISINFECTION

- A. After satisfactory testing, all plant water and water collection and distributed systems shall be thoroughly disinfected with a solution of not less than 50 ppm of available chlorine. The disinfecting solution shall be allowed to remain in the system for a period of three hours after which time all valves and faucets shall be opened and the system shall be flushed with clean water.
- B. Water being flushed from structures or pipelines after disinfection with a chlorine residual of two mg/l or greater, shall be treated with a dechlorination solution, in a method approved by the Engineer, prior to discharge

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SECTION 15140
PROCESS MECHANICAL PIPE HANGERS AND SUPPORTS

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. Furnish all labor, materials, equipment and incidentals and install a complete system of pipe hangers, supports, concrete inserts and anchor bolts including all metallic hanging and supporting devices for supporting non-buried piping as shown on the Drawings and as specified herein.
- B. The absence of pipe supports and details on the Drawings shall not relieve the Contractor of the responsibility for providing them. Pipe supports indicated on the Drawings are shown only to convey the intent of the design for a particular location and are not intended to represent a complete system.

1.02 RELATED WORK

- A. Concrete is included in Series 400.
- B. Metal Fabrications is included in Section 05500.
- C. Field painting is included in Division 9.
- D. Pipe and fittings are included in respective sections of Divisions 13 and 15.
- E. Valves and appurtenances are included in Section 15100.
- F. Hangers and supports pertaining to HVAC and Plumbing systems are included in their respective Sections.

1.03 SUBMITTALS

- A. Submit, in accordance with Section 01300, complete sets of shop drawings of all items to be furnished under this Section. Submittals shall include complete layouts, schedules, location plans and complete total bill of materials for all pipe support systems.
- B. Submittals shall include a representative catalog cut for each different type of pipe hanger or support indicating the materials of construction, important dimensions and range of pipe sizes for which that hanger is suitable. Where standard hangers and/or supports are not suitable, submit detailed drawings showing materials and details of construction for each type of special hanger and/or support. Provide detailed information on anti-seize compound.
- C. Submittals shall include complete piping drawings as submitted for each piping submittal indicating type of hanger and/or support, location, magnitude of load transmitted to the structure and type of anchor, guide and other pipe supporting appurtenances including structural fasteners.
- D. Types and locations of pipe hangers and/or supports shall also be shown on the piping layouts for each piping submittal as specified in the respective Division 15 pipe sections. Service

conditions for each piping system, including service temperatures, and operating and test pressures, are tabulated in the piping sections.

E. Submit complete design data for pipe support systems to show conformance with this Section.

F. Support System Design

1. Engage the services of an independent registered professional engineer ordinarily engaged in the business of pipe support systems analysis, to analyze system piping and service conditions and to develop a detailed support system, specific to the piping material, pipe joints, valves and piping appurtenances proposed for use.
 - a. The proposed support system engineer shall have at least five years of experience in the analysis and design of similar systems, including the use of commercial and custom pipe support and in the use of commercial pipe stress software programs. Provide a detailed resume, including references from projects within the past five years. The use of support systems engineer shall be subject to the approval of the Engineer.
2. The support system design shall include:
 - a. Criteria by piping system.
 - b. Summary of Contractor-selected related components including joints, class, valves appurtenances, etc., and commercial supports and especially including pipe materials.
 - c. Dead weight and dynamic analysis, including system thermal effects and pressure thrusts. Computer-based software system equivalent to ADLPIPE.
 - 1) Each system shall be presented in an isometric graphic and shall show the resolved and resultant force and moment systems, as well as all recommended hangers, supports, anchors, restraints and expansion/flexible joints.
 - d. Submit a draft report to the Engineer for approval.
 - 1) After the work is installed, but before it is filled for start-up and testing, the support system design engineer shall inspect the work and shall certify its complete adequacy. Each system shall be inspected and certified in the same way.
 - 2) Submit a report, including all field modifications and including all certificates.
 - 3) The report shall bear the stamp of a registered professional engineer and shall be subject to the approval of the Engineer.
 - e. All aspects of the analysis and design shall comply with the provisions of ANSI B31.1 and the referenced standards.
 - f. Support arrangements shall be coordinated to eliminate interference with similar systems to be installed under HVAC, Plumbing and Electrical; to account for structural expansion joints and to maintain access for both personnel and for the removal of equipment. Support systems shall not include the use of monorail or bridge crane support. Nor shall they rely on the horizontal structural struts.
 - g. Commercial hardware and custom supports shall comply with the requirements of this Section.
 - h. Expansion joints shall comply with the provisions of Section 15120.
3. Prepare for and attend a post-analysis review and presentation, after the Engineer's review of the report. Revise per the comments and issue as FINAL REPORT.

1.04 REFERENCE STANDARDS

- A. Manufacturer's Standardization Society of the Valve and Fittings Industry (MSS)
 - 1. MSS SP-58 - Pipe Hangers and Supports - Materials, Design and Manufacture.
 - 2. MSS SP-69 - Pipe Hangers and Supports - Selection and Application.
- B. ASTM International
 - 1. ASTM A36 - Standard Specification for Carbon Structural Steel.
 - 2. ASTM A307 - Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
- C. American National Standards Institute (ANSI)
 - 1. ANSI B31.1 - Power Piping.
- D. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

- A. All hangers, supports and appurtenances shall conform to the latest applicable requirements of ANSI B31.1, except as supplemented or modified by the requirements of this Section.
- B. All hangers, supports and appurtenances shall be of approved standard design where possible and shall be adequate to maintain the supported load in proper position under all operating conditions. The minimum working factor of safety for all supporting equipment, with the exception of springs, shall be five times the ultimate tensile strength of the material, assuming 10-ft of waterfilled pipe being supported.
- C. All pipe and appurtenances connected to equipment shall be supported in such a manner as to prevent any strain being imposed on the equipment. When manufacturers have indicated requirements that piping loads shall not be transmitted to their equipment, submit certification stating that such requirements have been complied with.

1.06 DELIVERY, STORAGE AND HANDLING

- A. All supports and hangers shall be crated, delivered and uncrated so as to protect against any damage.
- B. All parts shall be properly protected so that no damage or deterioration shall occur during a prolonged delay from the time of shipment until installation is completed.
- C. Finished metal surfaces not galvanized, that are not of stainless steel construction, or that are not coated, shall be grease coated, to prevent rust and corrosion.

PART 2 PRODUCTS

2.01 GENERAL

- A. All of the equipment specified herein is intended to support the various types of pipe and piping systems shown on the Drawings. It shall be the responsibility of the Contractor to develop final details and any details associated with special conditions not already covered to meet the system conditions (in particular system temperatures and pressures) specified in the respective Division 15 Pipe Sections.
- B. All pipe and tubing shall be supported as required to prevent significant stresses in the pipe or tubing material, valves, fittings and other pipe appurtenances and to support and secure the pipe in the intended position and alignment. All supports shall be designed to adequately secure the pipe against excessive dislocation due to thermal expansion and contraction, internal flow forces and all probable external forces such as equipment, pipe and personnel contact. Any structural steel members required to brace any piping from excessive dislocation shall conform to the applicable requirements of Section 05500 and shall be furnished and installed under this Section.
- C. The Contractor may propose minor adjustments to the piping arrangements in order to simplify the supports, or in order to resolve minor conflicts in the work. Such an adjustment might involve minor change to a pipe centerline elevation so that a single trapeze support may be used.
- D. Where flexible couplings are required at equipment, tanks, etc., the end opposite to the piece of equipment, tank, etc., shall be rigidly supported, to prevent transfer of force systems to the equipment. No fixed or restraining supports shall be installed between a flexible coupling and the piece of equipment.
- E. All pipe and appurtenances connected to the equipment shall be supported in a manner to prevent any strain from being imposed on the equipment or piping system.
- F. All rods, clamps, hangers, inserts, anchor bolts, brackets and components for interior pipe supports shall be furnished with galvanized finish, hot dipped or electro-galvanized coated, except where field welding is required, where cold-applied galvanizing may be used. Interior clamps on plastic pipe shall be plastic coated. Supports for copper pipe shall be copper plated or shall have a 1/16-in plastic coating. All rods, clamps, hangers, inserts, anchor bolts, brackets and components for exterior pipe, submerged pipe and pipe within outdoor structures shall be of Type 316 stainless steel.
- G. Supports shall be sufficiently close together such that the sag of the pipe is within limits that will permit drainage and avoid excessive bending stresses from concentrated loads between supports.
- H. All uninsulated non-metallic piping such as PVC, CPVC, etc., shall be protected from local stress concentrations at each support point. Protection shall be provided by galvanized steel protection shields or other method as approved by the Engineer. Where pipes are bottom supported 180 degrees, arc shields shall be furnished. Where 360 degree arc support is required, such as U bolts, protection shields shall be provided for the entire pipe circumference. Protection shields shall have an 18 gauge minimum thickness, not be less than 12-in in length

and be securely fastened to pipe with stainless steel or galvanized metal straps not less than 1/2-in wide.

- I. All insulated pipe shall be furnished with a rigid foam insulating saddle at each pipe support location as specified under respective pipe insulation. Provide protection shields as specified in at each support location.
- J. Where pipe hangers and supports come in contact with copper piping provide protection from galvanic corrosion by; wrapping pipe with 1/16-in thick neoprene sheet material and galvanized protection shield; isolators similar to Elcen, Figure No. 228; or copper plated or PVC coated hangers and supports. All stainless steel piping shall be isolated from all ferrous materials, including galvanized steel by use of neoprene sheet material and protection shields, similar to above methods.
- K. Pipe supports shall be provided as follows:
 1. Unless otherwise shown on the Drawings, cast iron and ductile iron, steel and stainless steel piping shall be supported at a maximum support spacing of 10-ft with a minimum of one support per pipe section at the joints.
 2. Insofar as is possible, floor supports shall be given preference. Typical concrete supports are shown on the structural drawings. Base elbow and base tees shall be used where possible.
 3. Support spacing for steel and stainless steel piping 2-in and smaller diameter and copper tubing shall not exceed 5-ft.
 4. For all stainless steel piping, provide neoprene isolators between the pipe and support components.
 5. Supports for multiple PVC plastic piping shall be continuous wherever possible. Individually supported PVC pipes shall be supported as recommended by the manufacturer except that support-spacing shall not exceed 3-ft. Multiple, suspended, horizontal plastic PVC pipe runs, where possible, shall be supported by ladder type cable trays such as the Electray Ladder by Husky-Burndy; the Globetray by the Metal Products, a Division of United States Gypsum, or equal. Ladder shall be of galvanized steel construction. Rung spacing shall be 12-in. Tray width shall be approximately 6-in for single runs and 12-in for double runs. Ladder type cable trays shall be furnished complete with all hanger rods, rod couplings, concrete inserts, hanger clips, etc., required for a complete support system. Individual plastic pipes shall be secured to the rungs of the cable tray by strap clamps or fasteners similar to Globe, Model M-CAC; Husky-Burndy, Model SCR or equal. Spacing between clamps shall not exceed 9-ft. The cable trays shall provide continuous support along the length of the pipe. Individual clamps, hangers and supports in contact with plastic PVC pipe shall provide firm support but not so firm as to prevent longitudinal movement due to thermal expansion and contraction.
 6. All vertical pipes shall be supported at each floor or at intervals of not more than 12-ft by approved pipe collars, clamps, brackets, or wall rests and at all points necessary to insure rigid construction. All vertical pipes passing through pipe sleeves shall be secured using a pipe collar.

7. Pipe supports shall not induce point loadings but shall distribute pipe loads evenly along the pipe circumference.
 8. Supports shall be provided at changes in direction and elsewhere as shown in the Drawings or as specified herein. No piping shall be supported from other piping or from metal stairs, ladders and walkways, unless specifically directed or authorized by the Engineer.
 9. Pipe supports shall be provided to minimize lateral forces through valves, both sides of split type couplings and sleeve type couplings and to minimize all pipe forces on pump housings. Pump housings shall not be utilized to support connecting pipes.
 10. Effects of thermal expansion and contraction of the pipe shall be accounted for in the pipe support selection and installation.
- L. Unless otherwise shown on the Drawings or specified herein, pipe hangers and supports shall be of standard catalogued components, conforming to the requirements of MSS-SP-58 and -69; and shall be as manufactured by Hilti, Tulsa, OK; Grinnell Co., Inc., Providence, RI; Carpenter & Patterson, Inc., Woburn, MA; F&S Central, Brooklyn NY; Elcen Metal Products Co., Franklin Park, IL and Unistrut Northeast, Cambridge, MA or approved equal. Any reference to a specific figure number of a specific manufacturer is for the purpose of establishing a type and quality of product and shall not be considered as proprietary.
- M. Any required pipe supports for which the supports specified in this Section are not applicable shall be fabricated or constructed from standard structural steel shapes, concrete and anchor hardware similar to items previously specified herein and shall be subject to the approval of the Engineer.
- N. Expansion anchors shall be equal to Kwik-Bolt as manufactured by the McCulloch Industries, Minneapolis, MN or Wej-it by Wej-it Expansion Products, Inc., Bloomfield, CO; or equal. The length of expansion bolts shall be sufficient to place the wedge portion of the bolt a minimum of 1-in behind the steel reinforcement.
- O. Hanger rods shall be hot rolled steel, machine threaded and galvanized after fabrication. The strength of the rod shall be based on its root diameter. Hanger rods shall be attached to concrete structures using concrete inserts similar to F&S, Figures 180, 571 or 150; or continuous concrete inserts per F&S. Inserts shall be malleable iron, or steel with galvanized finish. Beam clamps, C clamps or welded beam attachments shall be used for attaching hanger rods to structural steel members. Where necessary and approved by the Engineer, expansion anchors shall be used for attaching to concrete structures.

2.02 SINGLE PIPE HANGERS

- A. Single pipes shall be supported by hangers suspended by hanger rods from structural steel members, concrete ceilings, bottom of trapeze hangers and wall mounted steel angle brackets.
- B. Except as otherwise specified herein, pipe hangers shall be steel, of the adjustable clevis type similar to Grinnell, Figure No. 65, 260 and 590 as required.
- C. Where pipes are near walls, beams, columns, etc., and located an excessive distance from ceilings or underside of beams, welded steel wall brackets similar to Carpenter and Patterson, Figure No. 69-68, 84 or 139 shall be used for hanging pipe. Where single pipes rest on top of

bracket pipe supports, attachments shall meet requirements as specified under multiple pipe hangers.

2.03 MULTIPLE PIPE HANGERS

- A. Suspended multiple pipes, running parallel in the same horizontal plane, which are adjacent to each other shall be suspended by trapeze type hangers or wall brackets. Trapeze hangers shall consist of galvanized structural steel channel supported from galvanized threaded rod or attached to concrete walls, columns or structural steel support members as required to meet the intent of this Section. Channel shall be similar to F&S, Figure 710, rods, concrete inserts, "C" clamps, beam clamps, welded beam attachments and expansion shields shall be as specified in Paragraph 2.02 above.
- B. Except as otherwise specified herein pipe anchors used for attaching pipe to trapeze or multiple pipe wall brackets shall be anchor or pipe chairs similar to F&S, Figures 158, 419, 160A, 160B as required. Material of construction shall be galvanized steel. Chair "U" bolts shall be tightened to allow freedom of movement for normal expansion and contraction except where pipe must be anchored to control direction of movement or act as a thrust anchor.

2.04 SINGLE AND MULTIPLE PIPE SUPPORTS

- A. Single pipes located in a horizontal plane close to the floor shall be supported by one of the methods as shown on the Drawings and as specified herein.
- B. Pipes 3-in in diameter and larger shall be supported by adjustable stanchions similar to F&S, Figure 427. Stanchions shall provide at least 4-in adjustment and be flange mounted to floor.
- C. Pipes less than 3-in in diameter shall be held in position by supports fabricated from steel "C" channel, welded post base similar to Unistrut, Figure P2072A and pipe clamps similar to Unistrut, Figures P1109 thru P1126. Where required to assure adequate support, fabricate supports using two vertical members and post bases connected together by horizontal member of sufficient load capacity to support pipe. Wherever possible supports shall be fastened to nearby walls or other structural member to provide horizontal rigidity. More than one pipe may be supported from a common fabricated support.
- D. Where shown on the Drawings, pipe shall be supported using concrete anchor posts. Pipe shall be securely fastened to the posts using suitable metal straps as required and as approved.

2.05 WALL SUPPORTED PIPES

- A. Single or multiple pipes located adjacent to walls, columns or other structural members, whenever deemed necessary, shall be supported using welded steel wall brackets similar to Carpenter and Patterson, Figure No. 69-78, 84, or 134; or "C" channel with steel brackets similar to Unistrut pipe clamps. All members shall be securely fastened to wall, column, etc., using double expansion shields or other method as approved by the Engineer. Additional wall bearing plates shall be provided where required.
- B. Pipe shall be attached to supports using methods specified herein to meet the intent of this Section.

2.06 BASE ANCHOR SUPPORT

- A. Where pipes change direction from horizontal to vertical via a bend, a welded or cast base bend support shall be installed at the bend to carry the load. The base bend shall be fastened to the floor, pipe stanchion, or concrete pedestal using expansion anchors or other method as approved by the Engineer.
- B. Where shown on the Drawings, pipe bends shall be supported using concrete anchor posts. Pipes shall be securely fastened to the concrete supports with suitable metal bands as required and approved by the Engineer. A felt insert shall be used to isolate the piping from the poured concrete.

2.07 VERTICAL PIPE SUPPORTS

- A. Where vertical pipes are not supported by a Unistrut system as specified in Paragraph 2.08 below, they shall be supported in one of the following methods.
 - 1. For pipes 1/4-in to 2-in in diameter, an extension hanger ring shall be provided with an extension rod and hanger flange. The rod diameter shall be as recommended by the manufacturer for the type of pipe to be supported. The hanger ring shall be steel or PVC clad depending on the supported pipe. The hanger ring shall be equal to Carpenter & Paterson, Figure No. 81 or 81CT. The anchor flange shall be galvanized malleable iron similar to Carpenter and Patterson, Figure No. 85.
 - 2. For pipes equal to or greater than 2-in in diameter extended pipe clamps similar to Carpenter and Patterson, Figure No. 267 may be used. The hanger shall be attached to concrete structures using double expansion shields, or to steel support members using welding lugs similar to Carpenter and Patterson, Figure No. 220.
 - 3. Pipe riser clamps shall be used to support all vertical pipes extending through floor slabs. Riser clamps shall be steel similar to Carpenter and Patterson, Figure No. 126. Copper clad or PVC coated clamps shall be used on copper pipes. Insulation shall be removed from insulated pipes prior to installing riser clamps. Insulation shall not be damaged by clamp installation.
 - 4. Unless otherwise specified, shown, or specifically approved by the Engineer, vertical runs exceeding 12-ft shall be supported by base elbows/tees, clamps, brackets, wall rests and pipe collars, all located as required to ensure a rigid installation.

2.08 SPECIAL SUPPORTS

- A. Pipe supports shall be provided for closely spaced vertical piping systems required to provide a rigid installation. The interval of vertical support spacing shall be as specified, but in no case shall vertical interval exceed 10-ft. The support system shall consist of a framework suitably anchored to floors, ceilings or roofs.
- B. Vertical and horizontal supporting members shall be U shaped channels similar to Unistrut, Series P1000. Vertical piping shall be secured to the horizontal members by pipe clamps or pipe straps. All components shall be of steel.

- C. For piping 3-in and smaller, the framework shall be as manufactured by the Unistrut Corporation; Globe-Strut as manufactured by the Metal Products Division of U.S. Gypsum or equal. For piping larger than 3-in, the support frame shall be fabricated from structural steel shapes and secured through the use of expansion anchors.
- D. The assemblies shall be furnished complete with all nuts, bolts and fittings required for a complete assembly including end caps for all unistruts members.
- E. The design of each individual framing system shall be the responsibility of the Contractor. Shop drawings, as specified above shall be submitted and shall show all details of the installation, including dimensions and types of supports. In all instances the completed frame shall be adequately braced to provide a complete rigid structure when all the piping has been attached.
- F. Supports not otherwise described in this Section shall be fabricated or constructed from standard structural steel shapes in accordance with applicable provisions of Section 05500, or unistrut-type frame; have anchor hardware similar to items previously specified herein, shall meet the minimum requirements listed below and be subject to the approval of the Engineer.
 - 1. Pipe support systems shall meet all requirements of this Section and all related Sections.
 - 2. Complete design details of the pipe support system and system components shall be submitted for review and approval as specified in PART 1. No hanger or support shall be installed without the written approval of the Engineer.
 - 3. The pipe support system shall not impose loads on the supporting structures in excess of the loads for which the supporting structure is designed.

2.09 SUPPORTS FOR GROOVED DUCTILE IRON PIPING

- A. Grooved ductile iron piping systems proposed by the Contractor as substitute to the flanged ductile iron piping system shown on the Drawings and specified in Section 15072 shall be acceptable, in part, subject to the following hanger and support system revised requirements.
 - 1. Take extreme caution in any and all field cut grooves, due to the criticality of the dimensions and location of the grooves. No field grooved piping shall be assembled without the inspection and verification of the groove by the Contractor and in the presence of the Engineer. All couplings connected to a field groove shall be spot-painted.
 - 2. At each change in direction the piping shall be restrained against the axial direction of movement and against resultant pressure thrust, due to potential joint movement due to out-of-spec grooving.
- B. If, in the course of testing or operation there is any pipe movement, it shall require the removal of the length of pipe.

2.10 SURFACE PREPARATION AND SHOP PRIME PAINTING

- A. All surfaces shall be prepared and shop painted as part of the work of this Section. Surface preparation and shop painting shall be as specified in Section 09901.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Proceed with the installation of piping and supports only after any building structural work has been completed and new concrete has reached its 28-day compressive strength.
- B. The installation of pipe support systems shall in no way interfere with the operation of the overhead bridge cranes, monorails, access hatches, etc.
- C. The installed systems shall not interfere with maintenance and operational access to any equipment installed under this Section, or any other related Section.
- D. All pipes horizontal and vertical, requiring rigid support shall be supported from the building structure by approved methods. Supports shall be provided at changes in direction and elsewhere as shown in the Drawings or as specified herein. No piping shall be supported from metal stairs, ladders and walkways unless specifically directed or authorized by the Engineer.
- E. All pipe supports shall be designed with liberal strength and stiffness to support the respective pipes under the maximum combination of peak loading conditions to include pipe weight, liquid weight, liquid movement and pressure forces, thermal expansion and contraction, vibrations and all probable externally applied forces. Prior to installation, all pipe supports shall be approved by the Engineer.
- F. Pipe supports shall be provided to minimize lateral forces through valves, both sides of split type couplings and sleeve type couplings (within four pipe diameters) and to minimize all pipe forces on pump housings. Pump housings shall not be utilized to support connecting pipes.
- G. Inserts for pipe hangers and supports shall be installed on forms before concrete is placed. Before setting these items, all Drawings and figures shall be checked which have a direct bearing on the pipe location. Responsibility for the proper location of pipe supports is included under this Section.
- H. Continuous metal inserts shall be embedded flush with the concrete surface.
- I. Apply anti-seize compound to all nuts and bolts. Supports installed without the approved compound shall be dismantled and correctly installed, at no additional cost to the Owner.

3.02 TESTING

- A. All pipe support systems shall be tested for compliance with this Section. After installation, each pipe support system shall be tested in conjunction with the respective piping pressure tests. If any part of the pipe support system proves to be defective or inadequate, it shall be repaired or augmented under this Section to the satisfaction of the Engineer.

END OF SECTION

SECTION 15250
THERMAL INSULATION

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. This Section specifies the basic materials and methods of installation for insulation for piping and ductwork systems.

1.02 SUBMITTALS

- A. Submit, in accordance with Section 01300, the following for each insulation by System: manufacturer's product data showing conformance with this Section for all required insulations, jackets, covers, coatings, adhesives, fasteners, supports and appurtenances; and complete manufacturer's instructions for installation of all required items.
- B. All submittals shall contain a statement that Sections defining specific insulation types and thickness and all other referenced Sections have been read and complied with. The certification statement shall specify the specific Sections and be made by all of the following that are applicable; the Contractor, sub-contractor and the vendor. The statement shall be an individual statement for each party involved, and shall be included with every submittal and resubmittal.
- C. All materials deliveries must have accompanying manufacturers' certifications attesting to satisfactory results of product testing showing conformance with this Section.
- D. For units that will be shipped exposed, provide a description of the protective packaging that will be used during transit
- E. In general, corrections or comments or lack thereof made relative to submittals during review shall not relieve the Contractor from compliance with the requirements of the Drawings and Specifications. Submittals are for review of general conformance with the design concepts of the project and general compliance with the Contract Documents. The Contractor is responsible for the final design conforming and correlating all quantities and dimensions, selecting fabrication processes and techniques of construction, coordinating the work of all trades, and performing the work in a safe and satisfactory manner.

1.03 REFERENCE STANDARDS

- A. National Fire Protection Association (NFPA)
- B. Occupational Safety and Health Administration (OSHA)
- C. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.04 QUALITY ASSURANCE

- A. The insulation materials to be furnished under this Section shall be essentially the standard products of manufacturers regularly engaged in the manufacture of insulation systems.

- B. Several manufacturers are indicated as acceptable for each type of insulation in these Specifications. The Insulation Sub-contractor shall be responsible for determining that all insulation supplied for the project is suitable for installation in the spaces indicated. The Insulation Sub-contractor shall also insure that all materials used are compatible and in compliance with applicable codes and standards.
- C. The Owner and Engineer reserve the right to sample and test any materials after delivery and to reject all components represented by a sample that fails to comply with the specified requirements.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. All materials shall be inspected for size, quality, and quantity against approved shop drawings upon delivery.
- B. Delivery schedule of all equipment shall be coordinated with the Contractor. Equipment ready for shipment prior to the agreed on shipping date shall be stored without cost to the Owner by the manufacturer.
- C. All equipment shipped that is exposed, such as on a flatbed truck, shall be protected during transit. The equipment shall be protected from moisture, road salt, dirt and stones or other materials thrown up from other vehicles. Electrical components shall be protected as above, but with special attention to moisture. The method of shipment protection shall be defined in the submittals.
- D. All materials shall be suitably packed for shipment and long-term storage. Each package shall be labeled to indicate the project and the contents of each package. Where applicable, equipment numbers shall be marked on the container.
- E. All materials shall be stored in a covered dry location off of the ground. When protection of the materials is required, they shall be stored in a temperature-controlled location.

1.06 DEFINITIONS

- A. Particular terminology used under this Section is defined as follows:
 - 1. Traffic Level and Personnel Level - Areas, including process areas, equipment rooms, boiler rooms and other areas where insulation may be damaged by normal activity and local personnel traffic. Area extends to eight feet above floor, walkways, platforms and stairs, and horizontally three feet beyond the edge of walkways, platforms, and stairs.
 - 2. Exposed Piping and Ductwork - Piping and ductwork visible from the floor level and includes all piping and ductwork in equipment rooms, boiler rooms, etc.
 - 3. Concealed Piping and Ductwork - Piping and ductwork not visible from the floor level and includes piping and ductwork above hung ceilings and in shaftways.
 - 4. Supply Air Ductwork - Ductwork carrying air from a fan or air handling unit to the space or spaces to which it will be introduced. This air may have been heated or cooled. Supply air ductwork extends from the fan or air handling unit to the registers, grilles or diffusers at the end of the ductwork.

5. Return Air Ductwork - Ductwork carrying air from the space it was supplied to back to a fan or air handling unit. Return air ductwork extends from the registers or grilles at the end of the ductwork to the air handling unit or connection with an outdoor air intake duct.
6. Exhaust Air Ductwork - Ductwork carrying air from a space to a fan and then to be discharged to the outdoors. Exhaust air ductwork extends from the registers or grilles at the end of the ductwork to the fan. From the fan, the exhaust ductwork extends to the discharge point, exhaust air damper, or exhaust air plenum, whichever comes first.
7. Relief Air Ductwork - Ductwork carrying air from a space without a fan to be discharged to the outdoors. Relief air ductwork extends from the registers or grilles at the end of the ductwork to the discharge point, relief air damper, or relief air plenum, whichever comes first.
8. Outdoor Air Ductwork - Ductwork carrying untreated air from the outside to a fan or air handling unit. Outdoor air ductwork starts at the intake point, outdoor air damper, or outdoor air plenum, whichever comes last. The outdoor air ductwork extends to the fan, air handling unit, or connection with a return air duct, whichever comes first.
9. Mixed Air Ductwork - Ductwork that can carry either return air or outdoor air or a combination of both. Mixed air ductwork starts at the connection of the return air and outdoor air ducts and extends to the fan or air handling unit.
10. Outdoor Air Plenum - A plenum that extends from the opening in the skin of the structure to the outdoor air duct. If the outdoor air damper is directly at the intake or there is no outdoor air damper, the plenum will extend to the first size reduction. If the outdoor air damper is not at the intake, the plenum will extend to the outdoor air damper.
11. Exhaust Air Plenum - A plenum that extends from the opening in the skin of the structure to the exhaust air duct. If the exhaust air damper is directly at the discharge or there is no exhaust air damper, the plenum will extend from the last size reduction. If the exhaust air damper is not at the discharge, the plenum will extend to the exhaust air damper.
12. Relief Air Plenum - A plenum that extends from the opening in the skin of the structure to the relief air duct. If the relief air damper is directly at the discharge or there is no relief air damper, the plenum will extend from the last size reduction. If the relief air damper is not at the discharge, the plenum will extend to the relief air damper.
13. Ventilated Spaces - Areas supplied with outdoor air on a continuous or intermittent basis. The outdoor air may be heated and/or cooled or untreated.
14. Heated Spaces - Areas where heat is supplied to maintain a minimum temperature during the heating season.
15. Unheated Spaces - Areas where heat is not applied and there is no minimum temperature during the heating season.
16. Conditioned Spaces - Areas that are provided with heating and mechanical cooling.
17. Non-Conditioned Spaces - Areas that are not provided with mechanical cooling.

18. Indoor Piping - Piping within a building that is not exposed to the weather.
19. Outdoor Piping - Piping that is not within a building and which is exposed to the weather.
20. Indoor Ductwork - Ductwork within a building that is not exposed to the weather.
21. Outdoor Ductwork - Ductwork that is not within a building and is exposed to the weather.
22. Hot Ductwork - Ductwork carrying air with a temperature above the surrounding space temperature.
23. Cold Ductwork - Ductwork carrying air with a temperature below the surrounding space temperature.
24. Hot/Cold Ductwork - Ductwork carrying air with a temperature that can be either above or below the surrounding space temperature.

PART 2 PRODUCTS

2.01 GENERAL

- A. All materials and integrated insulation assemblies furnished shall have flame spread ratings of not over 25, and smoke developed rating of not over 50 as established by tests conducted in accordance with ASTM E84.
- B. The toxicity of the solvents used shall not exceed a maximum allowable concentration of 200 ppm or the latest value published by the American Conference of Governmental Industrial Hygienists and OSHA.
- C. Adhesives, coatings and vapor barrier materials shall be compatible with the insulation as recommended by the insulation manufacturer. Submit a certified statement attesting to the approval of the materials by the insulation manufacturer. Adhesives, sealants, mastics and coatings shall be manufactured by Foster; H.B. Fuller Construction Products; Childers; or approved equal. Foster and Childers (CP) numbers are listed below by adhesive/sealant/coating types.
 1. Lagging adhesive/coating: 30-36, CP-50, AMV-1 (LEED IEQ 4.2 compliant as a coating).
 2. Vapor barrier coating: 30-35, CP-30 (to meet LEED IEQ Credit 4.2, select water based, Foster 30-80, Childers CP-38).
 - a. Permeance shall be 0.013 perms or less at 43 mils dry per ASTM E96, Procedure B.
 3. Vapor seal lap adhesive: 85-20, CP-82 (to meet LEED IEQ Credit 4.1, select Foster 85-60).
 4. Duct insulation adhesive: 85-20, CP-82 (to meet LEED IEQ Credit 4.1, select Foster 85-60, Childers CP-127).
 5. Metal Jacketing/Flashing Sealant: 95-44, CP-76 (LEED IEQ 4.1 compliant).

6. Weather Barrier mastic (light gray): 46-51, CP-10-1. (LEED IEQ 4.2 compliant as a coating).

2.02 INSULATION FOR DUCTWORK-BLANKET TYPE (TYPE I-5)

- A. Insulation Material - Fibrous glass insulation, minimum density 0.75 lb/cu ft, maximum "K" factor of 0.29 at 75 degrees F mean temperature. Insulation shall comply with ASTM C1290 and C1136.
- B. Facing shall be factory applied vapor barrier 0.02 perm consisting of glass fiber scrim reinforced laminated facing of aluminum foil and Kraft paper.
- C. Acceptable manufacturers shall be Owens-Corning Fiberglas, Manville Corp., Certain-Teed, or equal.

2.03 INSULATION FOR DUCTWORK-FIBERGLASS BOARD TYPE (TYPE I-6)

- A. Insulation Material - Fibrous glass insulation, minimum density three pounds per cubic foot; maximum "K" factor of 0.24 at 75 degrees F mean temperature. Insulation shall comply with ASTM C612.
- B. Facing shall be factory applied vapor barrier 0.02 perm, consisting of glass fiber scrim reinforced laminated facing of aluminum foil and Kraft paper.
- C. Jacket
 1. Outdoor Ductwork – Jacket shall be field applied 0.016-inch-thick aluminum. Jacket shall include 0.003-inch-thick polyethylene that is laminated to the aluminum to create a moisture barrier.
- D. Acceptable manufacturers shall be Owens-Corning Fiberglas, Manville Corp., Certain-Teed, or equal.

2.04 INSULATION FOR COLD PIPING-CLOSE CELL FOAM TYPE (TYPE I-12)

- A. Insulation Material - Preformed flexible closed cell foam sheet, maximum "K" factor of 0.27 at 75 degrees F mean temperature. Insulation shall comply with ASTM C534, Type 1 – Tubular Grade 1.
- B. Jacket
 1. Outdoor Piping – Jacket shall be field applied 0.16-inch-thick aluminum. Jacket shall include 0.003-inch-thick polyethylene that is laminated to the aluminum to create a moisture barrier.
- C. Acceptable manufacturers shall be Armacell, or equal.

2.05 INSULATION FOR HOT PIPING (TYPE I-1)

- A. Insulation Material – Molded rigid fiberglass sectional pipe insulation rated to 850 degrees F. The insulation shall have a maximum “K” factor of 0.32 at 250 degrees F mean temperature. Insulation shall comply with ASTM C547, Type 1 to 850 degrees F.
- B. Jacket
 - 1. Jacket shall be field applied 0.016-inch-thick aluminum with a stucco embossed finish. Jacket shall include 0.003-inch-thick polyethylene that is laminated to the aluminum to create a moisture barrier.
- C. Fitting Covers
 - 1. Preformed aluminum covers.
- D. Acceptable manufacturers shall be Manville Corp., Certain-Teed, Owens-Corning Fiberglas, or equal.

PART 3 EXECUTION

3.01 GENERAL

- A. Do not apply insulation prior to testing and acceptance of piping, ductwork and/or equipment. Insulation shall not be applied to damp or frosty surface. Clean dust, dirt, grease and moisture from surfaces of pipe and ducts before applying insulation or insulation adhesives. Nameplates and equipment certification and data tags affixed to any piece of apparatus shall not be covered. Where two layers of insulation are used, stagger all joints both ways. Secure each layer independently. Continue insulation and jacketing through walls, partitions, floors and pipe sleeves except for partitions that are sealed with a mechanical seal.
- B. The Contractor shall not install any equipment or materials until the Owner and Engineer have approved all submittals. If any equipment or materials are installed prior to approval of the submittals, it shall be at the Contractor's risk.
- C. Insulation, adhesives, coatings and vapor barrier materials shall be applied in accordance with manufacturer's recommendations. Do not apply these materials when ambient temperature is above or below the maximum and minimum ambient temperature respectively, specified as limits by the manufacturer.
- D. All penetrations through a vapor barrier for hangers, instruments, etc., shall be sealed to provide a complete vapor barrier. The use of staples or other fasteners that penetrate the vapor barrier is not permitted.
- E. Insulation systems that require a vapor barrier shall be installed with an intact vapor barrier that covers the entire pipe, duct, or piece of equipment to be insulated. All edges of insulation that do not abut another piece of insulation shall have the vapor barrier extended, and sealed to the item being insulated. All penetrations through the insulation such as for thermowells, test ports, dampers, nameplates, or other items shall have the vapor barrier extend over the edges of the insulation and sealed to the item being insulated. Where items are mounted on ductwork, a

standoff shall be provided to protect the vapor barrier. The vapor barrier shall be sealed to the standoff.

- F. For insulated items exceeding 100 square feet, or 20 feet in length, extend the vapor barrier to the item being insulated to reduce the area or length within a single enclosed area to the dimensions listed above.

3.02 INSTALLATION OF PIPING INSULATION

- A. Pipe shields and pipe saddles for HVAC piping shall be provided as specified in Section 15815. Pipe shields and pipe saddles for process mechanical piping shall be provided as specified in Section 15140.
- B. Preformed sectional insulation and jacketing shall be used where possible. The use of blanket insulation will be limited to fittings that cannot be insulated with sectional insulation. All joints on preformed and fabricated insulation shall be accurately fitted to eliminate voids. Voids shall be eliminated by refitting or replacing the insulation. End joints shall be firmly butted to adjoining sections of insulation.
- C. Outdoor piping insulation shall be installed so as to keep the insulation dry. Joints shall be located to prevent the entrance of water. Breaks in jacketing caused by vertical connections or instruments shall be protected by hoods or cones. Where there are breaks in the jacket, plastic moisture barriers shall be provided under the jacketing to protect the insulation. Insulation and jacketing of valves shall be waterproofed. Insulation and jacketing of the valve shall be removable to allow servicing of the valve.
- D. Vapor seal adhesive shall be used to seal seams and to butt sections on all cold piping if self-sealing laps are not provided. The use of staples or any other fastening method that would penetrate the vapor barrier will not be permitted on cold piping systems. Staples may be used on hot piping systems where there is no potential for condensation.
- E. Metal or plastic jacketing shall have its joints staggered from those of the insulation. Joints between jacketing and insulation shall be staggered a minimum of three inches.
- F. Metal or plastic jacketing shall have a minimum three inch overlap on longitudinal joints and end joints. Longitudinal joints in horizontal piping shall have the outer lap of the joint pointed down to shed water. The end of the outer lap shall be located at the five or seven o'clock positions.
- G. Where piping is provided with electric or steam heat tracing, the insulation shall not be installed until the heat tracing has been tested and accepted. Insulation shall be sized to allow for the heat tracing line without deforming the insulation.
- H. Where supports, anchors or guides are in direct contact with cold piping, insulate the item in contact a distance of four times the insulation thickness. Clamps and non-welded support devices shall be contained within the insulation. The space within insulating saddles at pipe hangers shall be filled with insulation.
- I. On vertical risers exceeding 15 ft in height, provide intermediate support for the insulation. For carbon steel pipe, this support shall consist of angle clips or other suitable devices welded to the

pipe at about 15 ft on centers and concealed by the pipe covering. On non-carbon steel piping, clamps or other non-welded devices shall be used.

- J. Unless otherwise specified insulate all valves, control valves, fittings, pipe specialties and all other components that could be construed as being part of the piping system. Insulate valve bonnets to a point just below the stuffing box.
- K. Bridge flanges, unions, and pipeline strainers with block or sectional insulation wired in place. Wire shall be black steel, annealed. Stop the pipe insulation a sufficient distance to allow removal of flange bolts without disturbing the pipe insulation and extend the block at least two inches over the adjacent pipe insulation. Flange covers shall be designed for removal without damaging the pipe insulation. Fill voids with blanket insulation.
- L. Where there are lines run between two different piping systems, e.g., make-up water line between city water and chilled water, the interconnecting line shall be insulated the same as the system having the most rigid requirements. If one of the lines is not insulated, the interconnecting line shall be insulated the same as the insulated line.
- M. Where possible, all insulation shall be continuous through wall and floor openings and sleeves.

3.03 INSULATION FOR COLD PIPING CLOSED CELL FOAM (TYPE I-12)

A. Installation

- 1. Apply insulation in thicknesses indicated. Joints shall be sealed using self-sealing seams or adhesive.
- 2. Fittings shall be covered with the same insulation, mitered to fit.
- 3. Installation - Apply insulation in the thickness indicated. Attach insulation to sheet metal duct. Joints shall be made to have compression fit with the joints sealed with adhesive. Manufacturer's installation instructions shall be followed. Adhesives and coatings shall be provided by the insulation manufacturer and shall be compatible with the insulation. Insulation shall be provided with a protective finish for outdoor use in accordance with manufacturer's recommendations.

- B. Insulation thickness shall be as specified in the respective Piping System Sections.

3.04 INSULATION FOR COLD PIPING WITH VAPOR BARRIER (TYPE I-3)

A. Installation

- 1. Apply insulation in thicknesses indicated. Laps and joints shall be sealed using self-sealing laps or vapor barrier tape. Laps in horizontal piping shall be at the top. Seal ends of insulation sections at flanges, valves and fittings on 15-ft centers in straight pipe with vapor barrier coating that extends from vapor barrier jacket to the piping. All penetration of the vapor barrier shall be sealed vapor tight, including staples if used.
- 2. Where field-applied aluminum jacket is specified, the jacket shall be attached with aluminum draw bands located within 3 inches of each joint and 24 inches on centers, maximum. Jackets on outdoor piping shall have joints arranged to shed water.

3. Fittings shall be molded fiberglass or mitered sections of pipe insulation to provide the same insulation value as required for straight piping. PVC fitting covers, where specified, shall be sealed with vapor seal adhesive. Circumferential edges shall be wrapped with vapor barrier tape. Where preformed aluminum fitting covers are specified, a vapor barrier coating reinforced with glass cloth shall be applied directly to the insulation before installing the fitting cover. The vapor barrier shall be installed in accordance with the coating manufacturer's instructions. Aluminum fitting covers shall be attached with aluminum draw bands with joints located to shed water.

- B. Insulation thickness shall be as specified in the respective piping system section.

3.05 INSTALLATION OF DUCT INSULATION - GENERAL

- A. For purposes of insulation, flexible ductwork shall be treated as sheet metal ductwork.
- B. All cold ductwork shall be provided with a vapor barrier. Where the method of attachment causes penetrations of the vapor barrier, such penetrations shall be sealed with vaporseal adhesive and vapor barrier tape.
- C. All outside corners of ductwork in the traffic level shall be protected by sheet metal angles. Angles shall be 22 gauge galvanized steel with 2-inch legs. When the duct is constructed of materials other than galvanized steel, the protective angle shall be fabricated of the same material as the duct, or of equal corrosion resistance. If a different material of equal corrosion resistance is to be used, it must be approved by the Engineer. Angles shall be attached to the outside of the vapor barrier with adhesive. The entire inside surface of the corner angle shall be coated with adhesive before being installed.
- D. Clips, pins, washers, staples and other metal components shall be of the same material as the duct to be insulated. Where items of the same material are not available, a material of equal corrosion resistance may be used. If a different material of equal corrosion resistance is to be used, it must be approved by the Engineer.
- E. All joints in insulation shall be compressed 0.25-inch. Corner insulation shall be lapped with the overlap extending over the full thickness of the insulation layers. Open spaces in joints are not acceptable. A minimum of two layers of insulation shall be used when the required insulation thickness is greater than 2-inch. Joints in adjacent layers shall be staggered a minimum of 3 inches.

3.06 INSULATION FOR DUCTWORK-BLANKET TYPE (TYPE I-5)

A. General

1. Installation - Apply insulation in the thickness listed below. Adhere insulation to the duct surface with adhesive applied in strips 6-inch-wide on 12-inch centers. Butt all joints and lap jacket 2 inches over adjoining jacket. Seal all lap joints with vaporseal adhesive and staples. For ducts 30-inch-wide and over, additionally support insulation on bottom of duct with rows of welded or adhesive clips and washers on 18-inch centers. Seal penetrations, staples and terminations of vapor barrier with vapor barrier coating.
2. Insulation thickness shall be as specified in the respective ductwork system section.

3.07 INSULATION FOR DUCTWORK-FIBERGLASS BOARD TYPE (TYPE I-6)

A. General

1. Installation - Apply insulation in the thickness indicated. Fasten insulation to sheet metal duct with weld pins or approved adhered pins and clip washers. Place pins on 12-inch centers located near edge of insulation and with a minimum of two rows per side. Impale insulation on pins. Attach clip washers so that they rest on the surface of the insulation without indent. Cut off pins flush with surface of washers. Seal penetrations with aluminum vapor barrier coating. Groove insulation to cover standing seams or stiffeners. Extend vapor barrier facing continuously over standing seams or stiffeners to provide continuous seal. Seal joints and edges with 4-inch-wide strip of factory furnished vapor barrier facing adhered with vapor barrier adhesive or approved vapor barrier duct sealing tape to provide a continuous vapor barrier.
2. Insulation thickness shall be as specified in the respective ductwork system section.

3.08 INSULATION FOR HOT PIPING (TYPE I-1)

A. Installation

1. Apply insulation in thicknesses indicated. Laps and joints shall be sealed using self-sealing laps or outward clinch staples. Laps in horizontal piping shall be at the top.
2. Where field-applied aluminum jacket is used, the jacket shall be attached with aluminum draw bands located within 3 inches of each joint and 24 inches on center maximum. Jacket on outdoor piping shall have joints arranged to shed water.
3. Fittings shall be wrapped with blanket insulation to provide the same insulation value as required for straight piping. Aluminum fitting covers shall be attached by aluminum draw bands with joints located to shed water.

B. Insulation for Hot Piping (Type I-1). Insulation thickness shall be as follows:

| Facility | Service | Pipe Size | Insulation Thickness |
|---|-------------------------|---|----------------------|
| Gravity Thickeners and Odor Control Systems | Above ground NPW piping | 6-inch and below or as noted on Mechanical Drawings | 2-inch |

END OF SECTION

SECTION 15530
PACKAGED AIR CONDITIONING UNIT

PART 1 GENERAL

1.01 REFERENCES

- A. NFPA 90 A & B - Installation of Air Conditioning and Ventilation Systems and Installation of Warm Air Heating and Air Conditioning Systems.
- B. ANSI/ASHRAE 15 - Safety Code for Mechanical Refrigeration.
- C. ARI 360 - Commercial and Industrial Unitary Air Conditioning Equipment testing and rating standard
- D. NSI/ASHRAE 37 - Testing Unitary Air Conditioning Equipment.
- E. ANSI/ASHRAE/IESNA 90.1-1999 - Energy Standard for New Buildings.
- F. ANSI Z21.47/UL1995 - Unitary Air Conditioning Standard for safety requirements.
- G. ARI 210/240 - Unitary Air-Conditioning Equipment.
- H. ARI 270 - Sound Rating of Outdoor Unitary Equipment.
- I. ARI 370 - Sound Rating of Large Outdoor Refrigerating and Air Conditioning Equipment.
- J. NFPA 70-2008 - National Electric Code.

1.02 SUBMITTALS

- A. Submit unit performance data including: capacity, nominal and operating performance. Submit wiring diagrams, installation instructions, dimensions (including service areas), Manufacturer's startup instructions and shop drawings. Reference section 01300 for complete submittal requirements.

1.03 DELIVERY, STORAGE AND HANDLING

- A. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.

1.04 WARRANTY

- A. Provide warranty on entire installation, including parts, labor and refrigerant, for one year from date of substantial completion.
- B. Provide five-year extended warranty for compressors.
- C. Provide five-year heat exchanger limited warranty.

1.05 REGULATORY REQUIREMENTS

- A. Unit shall conform to ANSI Z21.47/UL1995 for construction of packaged air conditioner.
 - 1. In the event the unit is not UL approved, the manufacturer must, at his expense, provide for a field inspection by a UL representative to verify conformance to UL standards. If necessary, contractor shall perform modifications to the unit to comply with UL, as directed by the UL representative, at no additional expense to the Owner.

PART 2 PRODUCTS

2.01 SUMMARY

- A. Materials
 - 1. The contractor shall furnish and install package rooftop unit(s) as shown and scheduled on the contract documents. The unit(s) shall be installed in accordance with this specification and perform at the specified conditions as scheduled.
- B. Approved Manufacturers
 - 1. Units shall be manufactured by Lennox, McQuay, Carrier, York and Trane are considered equivalent, but equivalent features, specifications and configuration are required.

2.02 GENERAL UNIT DESCRIPTION

- A. Unit furnished and installed shall be packaged rooftop unit as scheduled on contract documents and these specifications or equivalent. Cooling capacity ratings shall be based on ARI Standard 210. Units shall consist of insulated weather-tight casing with compressors, air-cooled condenser coil, condenser fans, evaporator coil, return-air filters, supply motors and unit controls and drives.

2.03 UNIT CASING

- A. Cabinet: Galvanized steel, phosphatized, and finished with a factory finished paint coating with removable access panels. Structural members shall be 18 gauge with access doors and removable panels of minimum 20 gauge.
- B. Units cabinet surface shall be tested 1000 hours in salt spray test in compliance with ASTM B117.
- C. Cabinet top cover shall be one piece construction or where seams exists, it shall be double-hemmed and gasket-sealed.
- D. Access Panels: Water- and air-tight panels with handles shall provide access to filters, heating section, return air fan section, supply air fan section, evaporator coil section, and unit control section.
- E. Units base pan shall have a raised 1 1/8 inch high lip around the supply and return openings for water integrity.

- F. Insulation: Provide 1/2 inch thick fiberglass insulation with foil face on all exterior panels in contact with the return and conditioned air stream. All edges must be captured so that there is no insulation exposed in the air stream.
- G. Provide openings either on side of unit or through the base for power, control, condensate, and gas connections.

2.04 AIR FILTERS

- A. Air Filters: Filters shall be as noted on the Equipment Schedule on the drawings. Filter boxes on unit shall accommodate both types of filters with ready access for service.

2.05 FANS AND MOTORS

- A. Provide evaporator fan section with forward curved, double width, double inlet, centrifugal type fan.
- B. Provide self-aligning, grease lubricated, ball or sleeve bearings with permanent lubrication fittings, or permanently greased bearings.
- C. Outdoor and Indoor Fan motors shall be permanently lubricated and have internal thermal overload protection.
- D. Outdoor fans shall be direct drive, statically and dynamically balanced, draw through in the vertical discharge position.
- E. Provide shafts constructed of solid hot rolled steel, ground and polished, with key-way, and protectively coated with lubricating oil.

2.06 ELECTRIC HEATING SECTION

- A. Completely assembled and factory installed heating system shall be integral to unit, UL approved specifically for outdoor applications for use downstream from refrigerant cooling coils. Threaded connection with plug or cap provided.
- B. Electrical connection shall be integral to overall unit, for single point electrical connection.

2.07 EVAPORATOR COIL

- A. Provide configured aluminum fin surface mechanically bonded to copper tubing coil.
- B. Provide an independent expansion device for each refrigeration circuit. Factory pressure tested at 450 psig and leak tested at 200 psig.
- C. All coils shall be treated for protection from environment as noted on schedule.

2.08 CONDENSER COIL

- A. Provide vertical discharge, direct drive fans with aluminum blades. Fans shall be statically and dynamically balanced. Motors shall be permanently lubricated, with integral thermal overload protection in a weather tight casing.

2.09 REFRIGERATION SYSTEM

- A. Compressors: Provide scroll compressor with direct drive operating at 3600 rpm. Integral centrifugal oil pump. Provide suction gas cooled motor with winding temperature limits and compressor overloads.
- B. Units shall have cooling capabilities down to 0 degree F as standard. For field-installed low ambient accessory, the manufacturer shall provide a factory-authorized service technician that will assure proper installation and operation.
- C. Unit refrigeration circuits shall be as scheduled on the drawings.

2.10 OUTDOOR AIR SECTION

- A. Provide standard outside air hood on units.
- B. Provide energy recovery unit for rooftop units where shown.
- C. Provide spring return motor for outside air damper closure during unit shut-down or power interruption.

2.11 OPERATING CONTROLS

MICROPROCESS CONTROL

- A. Provide factory-wired roof top units with factory mounted microprocessor controls with control transformers, contactors pressure lugs or terminal block for power wiring. Unit shall include a factory mounted circuit breaker disconnect. Units shall have single point power connection as standard. Field wiring of zone controls to be NEC Class II.
- B. Provide factory-installed indoor evaporator defrost control to prevent compressor slugging by interrupting compressor operation.
- C. Provide an anti-cycle timing and minimum on/off between stages timing in the microprocessor.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Contractor shall verify that concrete pad is ready to receive unit.
- B. Contractor shall verify that proper power supply is available.

3.02 INSTALLATION

- A. Contractor shall install in accordance with manufacturer's instructions, the drawings and specifications.
- B. Mount units on level concrete foundation, with vibration isolation pad under each corner of unit.

END OF SECTION

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SECTION 15815
METAL DUCTS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:

1. Rectangular ducts and fittings.
2. Round ducts and fittings.
3. Sheet metal materials.
4. Sealants and gaskets.
5. Hangers and supports.

B. Related Sections:

1. Division 15 Section "Metal Duct Accessories" for duct-mounting access doors and turning vanes.
2. Division 15 Section "Testing, Adjusting, and Balancing" for testing, adjusting, and balancing requirements for metal ducts.

1.02 PERFORMANCE REQUIREMENTS

- A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article, Section 3.08.
- B. Structural Performance: Duct hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"
- C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2010.

1.03 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings:
 1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.

2. Factory- and shop-fabricated ducts and fittings.
 3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
 4. Elevation of top of ducts.
 5. Penetrations through fire-rated and other partitions.
 6. Equipment installation based on equipment being used on Project.
 7. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
 8. Hangers and supports, including methods for duct and building attachment and vibration isolation.
- C. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
 2. Penetrations of smoke barriers and fire-rated construction.

1.04 QUALITY ASSURANCE

- A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."
- B. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6.4.4 - "HVAC System Construction and Insulation."

PART 2 PRODUCTS

2.01 RECTANGULAR DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.
- B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-4, "Transverse (Girth) Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-5, "Longitudinal Seams - Rectangular Ducts," for static-pressure class, applicable sealing requirements, materials involved, duct-

support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

- D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 2, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.02 SHEET METAL MATERIALS

- A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
 - 1. Galvanized Coating Designation: G60.
 - 2. Finishes for Surfaces Exposed to View: Mill phosphatized.
- C. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
- D. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.03 SEALANT AND GASKETS

- A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
- B. Two-Part Tape Sealing System:
 - 1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
 - 2. Tape Width: 3 inches.
 - 3. Sealant: Modified styrene acrylic.
 - 4. Water resistant.
 - 5. Mold and mildew resistant.
 - 6. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
 - 7. Service: Indoor and outdoor.

8. Service Temperature: Minus 40 to plus 200 deg F.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
10. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Flanged Joint Sealant: Comply with ASTM C 920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.
6. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

2.04 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

- B. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 4-1, "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct."
- C. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.
- D. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
- E. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- F. Trapeze and Riser Supports:
 - 1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.

PART 3 EXECUTION

3.01 DUCT INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.
- B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.
- C. Install round ducts in maximum practical lengths.
- D. Install ducts with fewest possible joints.
- E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.
- F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
- G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.
- I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.
- J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal

flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

- K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers.
- L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "Duct Cleanliness for New Construction Guidelines."

3.02 INSTALLATION OF EXPOSED DUCTWORK

- A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.
- B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.
- C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.
- D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.
- E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.03 DUCT SEALING

- A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

3.04 HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Hangers and Supports."
- B. Building Attachments: Powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
 - 1. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
 - 2. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
 - 3. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
- C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 4-1, "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum

Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

- D. Hangers Exposed to View: Threaded rod and angle or channel supports.
- E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.
- F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.05 CONNECTIONS

- A. Make connections to equipment with flexible connectors complying with Division 15 Section "Metal Duct Accessories."
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.06 DUCT CLEANING

- A. Clean new duct system(s) before testing, adjusting, and balancing.
- B. Use service openings for entry and inspection.
 - 1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Division 15 Section "Metal Duct Accessories" for access panels and doors.
 - 2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
 - 3. Remove and reinstall ceiling to gain access during the cleaning process.

3.07 START UP

- A. Air Balance: Comply with requirements in Division 15 Section "Testing, Adjusting, and Balancing."

3.08 DUCT SCHEDULE

- A. Fabricate ducts with galvanized sheet steel.
- B. Supply Ducts:
 - 1. Ducts Connected to Unit:
 - a. Pressure Class: Positive 1-inch wg.
 - b. Minimum SMACNA Seal Class: A.
 - c. SMACNA Leakage Class for Rectangular: 24.

- d. SMACNA Leakage Class for Round and Flat Oval: 24.

C. Return Ducts:

- 1. Ducts Connected to Unit:
 - a. Pressure Class: Positive or negative 1-inch wg.
 - b. Minimum SMACNA Seal Class: A.
 - c. SMACNA Leakage Class for Rectangular: 24.
 - d. SMACNA Leakage Class for Round and Flat Oval: 24.

D. Intermediate Reinforcement:

- 1. Galvanized-Steel Ducts: Galvanized steel.

E. Elbow Configuration:

- 1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Elbows."
 - a. Velocity 1000 fpm or Lower:
 - 1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
 - 2) Mitered Type RE 4 without vanes.
 - b. Velocity 1000 to 1500 fpm:
 - 1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
 - 2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
 - 3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."
 - c. Velocity 1500 fpm or Higher:
 - 1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
 - 2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
 - 3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."
- 2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Elbows."
 - a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
 - b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
 - c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."
- 3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-3, "Round Duct Elbows."
 - a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
 - 1) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.

- 2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
- 3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
- 4) Radius-to Diameter Ratio: 1.5.
- b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
- c. Round Elbows, 14 Inches and Larger in Diameter: Standing seam or Welded.

F. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-6, "Branch Connections."
 - a. Rectangular Main to Rectangular Branch: 45-degree entry.
 - b. Rectangular Main to Round Branch: Spin in.
2. Round: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees." Saddle taps are permitted in existing duct.
 - a. Velocity 1000 fpm or Lower: 90-degree tap.
 - b. Velocity 1000 to 1500 fpm: Conical tap.
 - c. Velocity 1500 fpm or Higher: 45-degree lateral.

END OF SECTION 15815

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SECTION 15820
METAL DUCT ACCESSORIES

PART 1 GENERAL

1.01 SUMMARY

- A. Section Includes:
1. Turning vanes.
 2. Duct-mounted access doors.
 3. Flexible connectors.

1.02 ACTION SUBMITTALS

- A. Product Data: For each type of product.

1.03 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

PART 2 PRODUCTS

2.01 ASSEMBLY DESCRIPTION

- A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.02 TURNING VANES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Aero-Dyne Sound Control Co.
 2. CL WARD & Family Inc.
 3. Ductmate Industries, Inc.
 4. Duro Dyne Inc.
 5. Elgen Manufacturing.
 6. Hardcast, Inc.

7. METALAIRE, Inc.
8. SEMCO LLC.
9. Ward Industries; a brand of Hart & Cooley, Inc.

B. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

C. Vane Construction: Double wall.

2.03 DUCT-MOUNTED ACCESS DOORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Aire Technologies.
2. American Warming and Ventilating; a Mestek Architectural Group company.
3. Cesco Products; a division of MESTEK, Inc.
4. CL WARD & Family Inc.
5. Ductmate Industries, Inc.
6. Elgen Manufacturing.
7. Flexmaster U.S.A., Inc.
8. Greenheck Fan Corporation.
9. McGill AirFlow LLC.
10. Nailor Industries Inc.
11. Pottorff.
12. Ventfabrics, Inc.
13. Ward Industries; a brand of Hart & Cooley, Inc.

B. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2, "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."

1. Door:
 - a. Double wall, rectangular.

- b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
 - c. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
 - d. Fabricate doors airtight and suitable for duct pressure class.
2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
 3. Number of Hinges and Locks:
 - a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
 - b. Access Doors up to 18 Inches Square: Two hinges and two sash locks.
 - c. Access Doors up to 24 by 48 Inches: Three hinges and two compression latches.
 - d. Access Doors Larger Than 24 by 48 Inches: Four hinges and two compression latches with outside and inside handles.

2.04 FLEXIBLE CONNECTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. CL WARD & Family Inc.
 2. Ductmate Industries, Inc.
 3. Duro Dyne Inc.
 4. Elgen Manufacturing.
 5. Hardcast, Inc.
 6. JP Lamborn Co.
 7. Ventfabrics, Inc.
 8. Ward Industries; a brand of Hart & Cooley, Inc.
- B. Materials: Flame-retardant or noncombustible fabrics.
- C. Coatings and Adhesives: Comply with UL 181, Class 1.
- D. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches wide attached to two strips of 2-3/4-inch-wide, 0.028-inch-thick, galvanized sheet steel or 0.032-inch-thick aluminum sheets. Provide metal compatible with connected ducts.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.
- B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.
- C. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
 - 1. On both sides of duct coils.
 - 2. Upstream from duct filters.
 - 3. At outdoor-air intakes and mixed-air plenums.
 - 4. At drain pans and seals.
 - 5. Downstream from manual volume dampers, control dampers, backdraft dampers, and
 - 6. Upstream from turning vanes.
 - 7. Control devices requiring inspection.
 - 8. Elsewhere as indicated.
- D. Install access doors with swing against duct static pressure.
- E. Access Door Sizes:
 - 1. One-Hand or Inspection Access: 8 by 5 inches.
 - 2. Two-Hand Access: 12 by 6 inches.
 - 3. Head and Hand Access: 18 by 10 inches.
 - 4. Head and Shoulders Access: 21 by 14 inches.
 - 5. Body Access: 25 by 14 inches.
 - 6. Body plus Ladder Access: 25 by 17 inches.
- F. Label access doors to indicate the purpose of access door.

G. Install flexible connectors to connect ducts to equipment.

3.02 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Inspect locations of access doors and verify that purpose of access door can be performed.
2. Inspect turning vanes for proper and secure installation.

END OF SECTION 15820

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SECTION 15855
DIFFUSERS, REGISTERS, AND GRILLES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:

1. Louver face diffusers.

1.02 SUBMITTALS

A. Product Data: For each type of product indicated, include the following:

1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
2. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

B. Samples: For each exposed product and for each color and texture specified.

PART 2 PRODUCTS

2.01 CEILING DIFFUSERS

A. Rectangular and Square Ceiling Diffusers:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Krueger.
 - b. METALAIRE, Inc.
 - c. Price Industries.
 - d. Titus.
 - e. Tuttle & Bailey.
2. Devices shall be specifically designed for variable-air-volume flows.
3. Material: Steel or Aluminum.
4. Finish: Baked enamel, white.
5. Mounting: Surface or T-bar.
6. Accessories: See Schedule

B. Louver Face Diffuser:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. METALAIRE, Inc.
 - b. Price Industries.
 - c. Titus.
 - d. Tuttle & Bailey.
2. Devices shall be specifically designed for variable-air-volume flows.
3. Material: Steel or Aluminum.
4. Finish: Baked enamel, white.
5. Mounting: Surface.
6. Accessories: See Schedule

2.02 REGISTERS AND GRILLES

A. Fixed Face Register:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Krueger.
 - b. Price Industries.
 - c. Titus.
 - d. Tuttle & Bailey.
2. Material: Steel or Aluminum.
3. Finish: Baked enamel, white.
4. Face Arrangement: 1/2-by-1/2-by-1/2-inch grid core.
5. Frame: 1-1/4 inches wide.
6. Accessory: See Schedule.

B. Fixed Face Grille:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Krueger.
 - b. Price Industries.
 - c. Titus.
 - d. Tuttle & Bailey.
2. Material: Steel or Aluminum.
3. Finish: Baked enamel, white.

4. Frame: 1-1/4 inches wide.
5. Accessory: See Schedule.

2.03 SOURCE QUALITY CONTROL

- A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install diffusers, registers, and grilles level and plumb.
- B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.
- C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.02 ADJUSTING

- A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

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SECTION 15891
FIBERGLASS REINFORCED PLASTIC DUCTWORK AND ACCESSORIES

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. Furnish, fabricate, and install all fiberglass reinforced plastic (FRP) ductwork including fittings, accessories, dampers, hangers, and any incidental work or components required and provide complete air supply, return and exhaust ductwork systems, as shown on the Drawings and as specified herein.
- B. Design, furnish, and install seismic restraints and braces for all ductwork and accessories.
- C. In general, ductwork shall consist of any passageway made of FRP substantially air-tight, used for the conveying of air, gas, or materials. Included are fittings, transitions, bracing, fasteners, sealers, supports, and accessories such as access panels, access doors, turning vanes and manual air balancing dampers. All ductwork shall be of size and material as specified herein and as shown on the Drawings. All duct sizes indicated on the Drawings are clear, inside dimensions.
- D. Any change in duct sizes, offsets, transitions, and fittings required to accommodate job conditions shall be submitted to Engineer for approval.
- E. All ductwork, piping, and equipment shown on the Drawings is intended to be approximately correct to scale, but figured dimensions and detailed drawings of the actual equipment furnished shall be followed in every case. The Drawings shall be taken in a sense as diagrammatic. Size of ductwork and piping are shown, but it is not the intent to show every offset or fitting, nor every hanger or support, or structural difficulty that may be encountered. To carry out the intent and purpose of the Drawings, all necessary parts to make a complete working system ready for use shall be furnished without extra charge. The Contractor shall be responsible to coordinate the system installation and routing with the work of all trades.

1.02 RELATED WORK

- A. Odor Control Bioscrubber System is specified in Section 11258.
- B. Testing, Adjusting and Balancing is specified in Section 15950.

1.03 SUBMITTALS

- A. Submit, in accordance with Section 01300, the following:
 - 1. Ductwork shop drawings shall include typical details of discharge nozzles, transitions, elbows, fittings, accessory items such as access panels or access doors, turning vanes, volume control and splitter dampers, volume extractors, hangers, joining methods, bracing and material gauges. Drawings of general layouts of individual systems shall be submitted, scale shall be 1/4-in. = 1-ft.-0-in. minimum.

- B. The following additional data shall be submitted:
1. Manufacturer's qualification and experience data, specifications and installation instructions, factory and field quality control procedures catalog data, brochures, descriptive matter, illustrations, diagrams and color charts of ductwork to be selected.
 2. Specific handling and storage requirements for ductwork, joint kits, and resin systems.
 3. For units that will be shipped exposed, provide a description of the protective packaging that will be used during transit.
 4. Sample coupons of laminate not less than 1-ft. square. Provide sample laminate coupons for each method of manufacture and for both round and rectangular duct manufacturing methods.
 5. Resin system data, including chemical environment service test data, case history data of similar installations (with contact addresses), resin pot life and time versus temperature data required for complete resin cure for laminate thicknesses actually proposed.
 6. Submit design calculations signed and sealed by a professional engineer and fabrication procedures for record purposes only. Also submit a letter certifying that the laminates fabricated with the proposed resin system will give satisfactory performance under the specified service conditions and stating the service conditions for which certification is provided and indicating compliance with specified pressure and vacuum design criteria.
 7. Submit construction details for flexible connectors, expansion joints, elbows, transitions, junctions and flanged fittings including dimensioned laminate cross sections and flange fabrication and assembly details.
 8. Submit results of factory readings taken with "Barcol Hardness Impressor" and provide procedure to field check for complete cure of resin.
 9. Certified service tables for the resins being used and the expected contaminants showing satisfactory services for the required design conditions.
 10. Detailed instructions for field joining of the ductwork to include quality control procedures.
 11. Submit shop test reports for fiberglass reinforced plastic dampers.
- C. In general, corrections or comments or lack thereof made relative to submittals during review shall not relieve the Contractor from compliance with the requirements of the drawings and specifications. Submittals are for review of general conformance with the design concepts of the project and general compliance with the contract documents. The Contractor is responsible for the final design conforming and correlating all quantities and dimensions, selecting fabrication processes and techniques of construction, coordinating the work of all trades, and performing the work in a safe and satisfactory manner.

1.04 REFERENCE STANDARDS

- A. ASTM International
 - 1. ASTM C581 - Standard Practice for Determining Chemical Resistance of Thermosetting Resins Used in Glass-Fiber-Reinforced Structures Intended for Liquid Service.
- B. National Fire Protection Association (NFPA)
 - 1. NFPA 90A - Standard for the Installation of Air Conditioning and Ventilation Systems.
 - 2. NFPA 91 - Standard for Exhaust Systems for Air Conveying of Materials.
 - 3. NFPA 252 - Standard Methods of Fire Tests of Door Assemblies.
- C. Underwriters Laboratories (UL)
 - 1. UL 555 - UL Standard for Safety Fire Dampers.
- D. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE)
- E. American National Standards Institute (ANSI)
 - 1. ANSI RTP-1 - Reinforced Thermoset Plastic Corrosion Resistant Equipment.
- F. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

- A. All FRP duct and fittings shall be from a single manufacturer.
- B. All materials shall be supplied by a manufacturer experienced in the fabrication of materials similar to those specified. Design and engineering shall be performed by personnel regularly employed by the manufacturer who are experienced in the design of FRP systems similar to those specified.
- C. The manufacturer shall provide factory-trained personnel for training of installers and for supervision and inspection of the installation. The use of local sales representatives for this service is not acceptable.
- D. Corrosion resistance data shall be based on ASTM C581.
- E. Inspection by the Engineer's representative, or failure to inspect, shall not relieve the Contractor of responsibility to provide materials and perform the work in accordance with the documents.
- F. The Owner and Engineer reserve the right to sample and test any materials after delivery, and to reject all components represented by a sample that fails to comply with the specified requirements.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Equipment, material, and spare parts are to be shipped complete, except where partial disassembly is required by transportation regulations or for protection of components. No ductwork or components shall be shipped prior to complete resin cure.
- B. Inspection of the duct and components will be made by the Engineer or other representative of the Owner after delivery. Materials shall be subject to rejection at any time on account of failure to meet any of the specified requirements. Material rejected after delivery shall be marked for identification and shall be immediately removed from the job site.
- C. All materials shall be inspected for size, quality, and quantity against approved shop drawings upon delivery.
- D. Delivery schedule of all equipment shall be coordinated with the Contractor. Equipment ready for shipment prior to the agreed-on shipping date shall be stored without cost to the Owner by the manufacturer.
- E. All materials shall be suitably packed for shipment and long-term storage. Each package shall be labeled to indicate the project and the contents of each package. Where applicable, equipment numbers shall be marked on the container.
- F. All equipment shipped that is exposed, such as on a flatbed truck, shall be protected during transit. The equipment shall be protected from moisture, road salt, dirt and stones or other materials thrown up from other vehicles. Electrical components shall be protected as above, but with special attention to moisture. The method of shipment protection shall be defined in the submittals.
- G. All materials shall be stored in a covered dry location off of the ground. When required to protect the materials, they shall be stored in a temperature-controlled location.

1.07 COORDINATION

- A. The drawings indicate the extent and general arrangement of the systems. If any departures from the drawings or specifications are deemed necessary, details of such departures and the reasons therefore shall be submitted as soon as practical for review. No such departures shall be made without the prior written concurrence of the Engineer.
- B. The Contractor shall coordinate the location and placement of all concrete inserts and welding attachments with the structural engineer.
- C. The Contractor shall assume full responsibility for coordination of the HVAC systems, including; scheduling, and verification that all structures, ducts, piping and the mounting of equipment are compatible.
- D. The Contractor shall not install any equipment or materials until the Owner and Engineer have approved all submittals. If any equipment or materials are installed prior to approval of the submittals, it shall be at the Contractor's risk.

1.08 SPARE PARTS

- A. Spare parts shall include all special items on the manufacturer's standard list of spare parts.
- B. In addition to special items, the following spare parts shall be provided:
 - 1. Furnish all special tools required for normal operation and proper servicing of the equipment.
 - 2. Provide a minimum of one, or 5 percent of the total units rounded to the next full unit, whichever is greater, for each size and rating of the following component:
 - a. Damper operators
- C. Pack spare parts in containers suitable for extended storage without deterioration of the parts. Containers shall be clearly labeled designating contents, pieces of equipment for which intended, and equipment identification numbers.

1.09 STANDARDS OF CONSTRUCTION AND INSTALLATION

- A. All ductwork construction and installation details shown on the Drawings and specified herein are based on acceptable methods of construction and installation and are intended to define the quality of construction and installation to be furnished. Alternate details may be submitted for approval.

1.10 ENGINEERING SERVICES

- A. When engineering services are specified to be provided by the Contractor, the Contractor shall retain a licensed professional engineer to perform the services. The engineer shall be licensed at the time the work is done and in the State in which the project is located. If the State issues discipline specific licenses, the engineer shall be licensed in the applicable discipline. In addition, the engineer shall be experienced in the type of work being provided.
- B. All work is to be done according to the applicable regulations for professional engineers, to include signing, sealing and dating documents. When submittals are required by a professional engineer, in addition to state required signing and sealing, a copy of the current wallet card or wall certificate indicating the date of expiration shall be included with the submittal.

PART 2 PRODUCTS

2.01 MATERIAL

- A. Design Conditions
 - 1. Temperature: minus 10 to 125 degrees F
 - 2. Pressure: 10-in H2O w.g. positive; 10-in H2O w.g. negative
 - 3. Flow medium and velocity: air at 2500 fpm
 - 4. Wall thickness (minimum):
 - a. Up to 36-in. diameter - 0.187-in. struct. wall plus 0.10-in. liner

b. 38 to 60-in. diameter - 0.250-in. struct. wall plus 0.10-in. liner

- B. The following materials are expected to be in the air stream or surrounding area. The resins used shall be suitable for all of the following:
1. Hydrogen sulfide and other odorous compounds in 100 percent relative humidity air typically found at wastewater treatment plants. Some dilute sulfuric acid.

2.02 CLASSES OF CONSTRUCTION

- A. Ductwork shall be designed and constructed for the following services and in accordance with ANSI RTP-1.
- B. Design of ductwork shall include all loads applied to the ductwork, in addition to the load of the duct. These loads include but are not limited to wind, snow and internal dirt or liquid buildup.

2.03 FIBERGLASS REINFORCED PLASTIC (FRP) DUCTWORK

- A. FRP ductwork shall be of contact molded or filament wound construction, or a combination of these methods, to meet design criteria.
- B. FRP ductwork shall have a flame spread rating of 25 or less inside and outside in accordance with NFPA 91. Indoor ductwork shall have smoke developed rating of not more than 50. Sprinklers shall not be used for internal fire suppression.
- C. Laminates shall consist of a 20 mil (finished thickness) minimum chemical resistant interior liner with an apertured synthetic surface veil embedded in a resin rich surface. The corrosion barrier shall be a minimum of 100 mils thick and include not less than two layers of 1-1/2 oz. 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 "C" - glass or apertured nexus veil not less than 20 mils thick. Outside finish shall be a pigmented, parafinated gel coat with an ultra violet inhibitor. The inner surface shall be free of cracks and crazing with a smooth finish and with an average of not over two pits per square foot, providing the pits are less than 1/8-in. in diameter and not over 1/32-in. deep and are covered with sufficient resin to avoid exposure of inner surface fabric. Some waviness is permissible as long as the surface is smooth and free of pits.
- D. Resins used in the laminate shall be premium corrosion resistant and fire retardant vinylester resins and shall contain 3 percent NYACOL as a fire retardant.
- E. Fittings and Joints: All fittings such as elbows, laterals, tees and reducers shall be of the same resin as an equal or superior in strength to the adjacent duct section and shall have the same internal dimensions as the adjacent duct. Non-flanged duct joints shall be butt wrapped or bell and spigot joints. Bell and spigot joints shall be sealed with a standard butt joint overlay as per PS 15-69. The interior opening between the bell and spigot shall be sealed with a resin paste so that no glass fibers are exposed and all voids are filled. Field cut duct ends and exposed glass fibers shall be resin coated prior to joint assembly to maintain a continuous interior corrosion barrier. Coat all exterior surfaces of joints with a parafinated resin-rich gel coat with UV inhibitors.

- F. Total width of overlay for butt-wrap joints shall be not less than 6-in. for diameters from 6-in. up to and including 30-in., 36-in. and larger shall be not less than 10-in.
- G. Round Standard Elbows
1. Standard elbow centerline radius shall be equal to 1-1/2 times the diameter.
 2. Standard elbows up to 24-in. diameter shall be smooth radius molded elbows. Standard elbows 30-in. diameter and greater may be mitered sections as specified below.
 3. Zero 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.
- H. Rectangular Fittings
1. Fittings shall be factory manufactured to meet the specified design criteria and in accordance with approved submittals. Factory install reinforcing ribs as required to meet the specified deflection requirements and to provide a system free from pulsing, warpage, sagging and undue vibration.
 2. Provide forming vanes in all mitered rectangular elbows. Rectangular elbow turning vanes shall be of FRP construction, solid or double wall construction with an airfoil shaped profile.
- I. Reinforcing
1. Round duct reinforcing shall be factory installed with spacing between reinforcing located to avoid all hangers and support saddles.
 2. Rectangular duct and fitting reinforcing shall be factory located and installed to avoid duct hangers, support saddles, bracing, branch take-offs and entries, and plenum connections. Routine field cutting and field relocation of factory-installed reinforcing is not acceptable.
- J. Tolerances
1. Out-of-roundness of duct shall be limited to plus or minus 1/8-in. or plus or minus 1 percent of duct inside diameter, whichever is greater, for duct sizes 6-in. diameter and greater.
 2. Rectangular duct tolerances shall be 3/16-in. for duct diameter up to 18-in. and plus or minus 1 percent for dimensions of over 18-in.
 3. All unflanged duct shall be square on the ends in relation to the pipe axis and plus or minus 1/8-in. up to and including 24-in. diameter and plus or minus 3/16-in. for all diameters greater than 24-in.
 4. Fittings
 - a. The tolerance on angles of all fittings shall be plus or minus 1 degree, up to and including 24-in. diameter and plus or minus 1/2 degree for 30-in. 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 plus or minus 1/32-in., up to and including 18-in. diameter and flat within plus or minus 1/16-in. for 20-in. diameter and larger.
- c. Provide custom filler pieces as required to mate flanges squarely.

K. Calculations for wall thickness determination shall be based on the structural fiberglass reinforced wall only. Long term deflection shall not exceed 1 percent of duct diameter or duct width for rectangular ducts. Round and rectangular FRP ductwork shall be designed using a safety factor of 10 to 1 for pressure and 5 to 1 for vacuum service. Round duct shall be designed by manufacturer to resist specified loadings but in no case shall FRP duct be less than the following thicknesses:

| Diameter (- in.)* | Filament Wound Thickness (-in.) | Hand Layup Thickness (-in.) |
|----------------------|--|--------------------------------------|
| Less than 24 | 225 | .25 |
| 24 to 30 | 275 | .313 |
| 36 to 42** | 375 | .438 |
| 48 to 60** | 525 | .688 |
| 66 to 72** | 625 | .813 |

* Where rectangular duct is used the longest dimension shall be considered equivalent to diameter.

** Rectangular duct may be reinforced with angles or tees as required to meet the required pressure/vacuum service.

L. All connections to expansion joints, butterfly dampers, fire dampers, tanks, or other equipment shall be flanged. Gaskets shall be chlorobutyl. Flanges shall be hand laid up to thickness specified in PS 15-69 except that minimum thickness shall be 3/4-in. Each flange face shall be ground flat, and a new 100 mil corrosion barrier shall be applied. The flange shall be anchored to a waxed table to ensure the flatness tolerance outlined above. The face shall be textured for use with full face chlorobutyl gaskets, 1/8-in. minimum thickness. Flange drilling shall be as per PS 15-69. All bolt holes shall be back spot faced for a washer seat. All flange bolts shall be torqued to values as recommended by manufacturer.

M. Fasteners: Furnish all bolts, nuts, washers and other fasteners required. Material of metallic fasteners shall be Type 316 stainless steel.

N. There shall be not less than a 1/4-in. buildup of FRP over the duct at each support and as shown on the Drawings.

O. Provide 1-in. minimum PVC pipe and PVC ball valve duct drains in the bottom of all main, branch and riser ducts to allow removal of condensate.

2.04 FLEXIBLE CONNECTORS

- A. Flexible fabric connectors for vibration isolation shall be airtight, watertight, fire retardant, 6-in wide with 3-in. metal edges. Metal edges and fasteners shall be the same material or greater corrosion resistance as the duct.
1. Flexible connections for conventional indoor HVAC systems shall be glass fabric coated with polychloroprene. Fabric must comply with Underwriters Laboratories Standard UL214 and NFPA Bulletin 90A. Connections shall be Ventglas by Ventfabrics or equal.
 2. Flexible connection for outdoor conventional HVAC systems ductwork shall be glass fabric coated with Dupont Hypalon Fabric and must be resistant to sunlight, ozone and weather. Fabric must comply with Underwriters Laboratories Standard UL214 and NFPA Bulletin 90A. Connection shall be Ventlon by Ventfabric or equal.
 3. Flexible connections for process exhaust systems shall be fiberglass fabric coated with Dupont teflon. Fabric must be resistant to Hydrogen sulfide. Fabric must comply with Underwriters Laboratories Standard UL214 and NFPA Bulletin 102. Connections shall be Ventel by Vent Fabric, or equal.
- B. Furnish flexible connectors at each inlet and outlet of fan and in the duct runs where required for expansion, contraction and movement. Flexible connections shall be integral flange molded arch type units constructed of EPDM rubber 1/4-in. thick, reinforced with a strong synthetic asbestos-free fabric suitable for corrosive service. The flexible connections shall be designed to minimize the transmission of vibration from the fans to the ductwork at the suction and discharge connections. Expansion or contraction flexible connections shall be designed to allow 1-in movement. Working length or "live" length shall be as designed by the manufacturer to allow up to 1-in of movement. Ends shall be flanged, with flanges matching duct connection flanges. 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 minus 10 up to 125 degrees F, and pressure to 5 psig. Specially fabricated split Type 316 stainless steel retaining back-up bars shall be supplied to prevent damage to the EPDM rubber flanges when Type 316 stainless steel bolts are tightened.
- C. Where the construction of the flexible connections or vibration isolator results in a cross sectional area of the connection which is less than 90 percent of the adjacent ductwork, the size of the connection shall be increased to provide a cross sectional area equal to or greater than 90 percent of the adjacent duct.
- D. Provide flexible duct connections at both the intake and discharge connections for all fans and air handling units except as noted below.
1. Wall and roof fans that have integral motor/fan wheel isolation.
 2. Air handling units where the fan is isolated from the intake and discharge connections by internal flexible connections or separations, and the unit is mounted without vibration isolators between the unit and the support structure.
- E. Ductwork spacing and alignment for flexible connections shall be aligned to the tolerances of the flexible connection manufacturer, or plus/minus 1/4-in., whichever is less. Bolts shall be torqued to the manufacturer's recommendations. Do not over tighten.

F. Where flexible connections are used as expansion joints, the manufacturer's pre-compression recommendations must be followed. When the temperature at installation differs from the temperature in the pre-compression recommendation, a correction shall be made.

G. Manufacturer:

1. Holz Rubber Company.
2. Mercer Rubber Company.
3. Proco Products Incorporated.
4. Or equal.

2.05 TOOLS, SPARE PARTS AND MAINTENANCE MATERIALS

A. The duct system shall be furnished with the following:

1. One set of special tools required to maintain and repair the system.
2. All materials in kit form to make or repair joints. Additional kits shall be supplied sufficient to repair 10 percent of the joints. Materials shall be packaged for long-term storage.
3. Names and addresses of all manufacturers of fiberglass reinforcements, resins, hardeners and components used to repair and maintain the FRP duct system.

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.

C. Material safety data sheets for all components must be furnished.

2.06 FIBERGLASS REINFORCED PLASTIC DAMPERS

A. Furnish and install where indicated on the Drawings manually operated butterfly or parallel blade dampers, with handle for manual operation and positive locking quadrant for balancing purposes. Dampers shall be flanged connection and fabricated from materials similar to those specified in Paragraph 2.03 above.

B. Locking quadrants shall have a positive method of holding the damper in its selected position such as a bolt through both the quadrant and the lever arm. Systems using springs or other devices that can vibrate loose are not acceptable.

C. Rating Conditions

1. Velocity through Damper: 4000 fpm.
2. Pressure Rating: 20-in water column.
3. Allowable Leakage: With a differential pressure of 12-in. w.g.

| Size (in Diameter) | Maximum Allowable Leakage (cfm) |
|--------------------|---------------------------------|
| 72 | 200 |
| 66 | 186 |
| 60 | 172 |
| 54 | 158 |
| 42 | 130 |
| 36 | 50 |
| 24 | 25 |
| 18 | 20 |

4. One damper of each size shall be shop tested at 12-in. w.g. differential and shall meet the above leakage. Submit damper test report to the Engineer. Damper shall not be shipped until approved by the Engineer.

D. Materials

1. Bearings, Teflon
2. Blade: FRP, angle reinforced.
3. Frame: FRP.
4. Axles: FRP rods, full length of damper size as shown on the Drawings.
5. Finish: FRP.
6. Handle: Type 316 stainless steel, or FRP.
7. Pins: Type 316 stainless steel.
8. Blade Stops: FRP angles with elastomer seals suitable for use at the design conditions.
9. Bushings: Teflon.
10. Hardware: Type 316 stainless steel.
11. Angles: FRP.

E. Dimensions: As detailed on the Drawings.

F. Manufacturer: Provide products of one of the following:

1. Ershigs Incorporated.
2. Bionomic Industries, Interchem Systems Division.
3. Heil Process Equipment, Xerxes Corporation.
4. Swartwout, Phillips Industries.

5. Calgon Corporation.

6. Or equal.

2.07 FRP TRANSITION PIECES

- A. Provide transition pieces as shown on Drawings and specified herein.
- B. Construction:
 - 1. Thickness of transition pieces shall be designed using a safety factor of 10 to 1 for pressure and 5 to 1 for vacuum service with the pressure classification listed below.
 - 2. Custom flanges shall be designed as required to connect to fans, coils, dampers and duct work. Coordinate flange sizes to match approved equipment dimensions.
- C. Pressure Classification: Manufacturer shall design transition pieces so that they shall be free from buckling, pulsing, warpage and sagging at design pressures.

2.08 LABELS

- A. The service of each duct along with an arrow indicating direction of flow shall be provided on each duct system. Labels shall be located not more than 26 linear feet apart and shall also be provided at both sides of wall penetrations, at each damper, and each equipment connection.
- B. Labels shall contain the service spelled out, the duct size, and the equipment number of the equipment served. Label locations shall have unobstructed view from normal viewing locations.
- C. Numbers and letters shall be die-cut from 3.5 mil vinyl film and pre-spaced on carrier film. Adhesive and finish shall be protected with one piece removable liners. Colors shall be white letters on black backgrounds.
- D. The system for preparation and application of letters shall be Type B a.s.i./2 by ASI Sign Systems; Architectural Graphics Inc., or equal. Letters shall be 3-in. high Optima Bold, upper case using Grid 2 spacing. Direction arrows are to match. The instructions of the manufacturer shall be followed in respect to storage, surface preparation and application of letters.
- E. Each piece of equipment is to be provided with an identification label listing the unit number and the areas served. Labels shall be as specified above.
- F. Service identifications are to be as follows:

SUPPLY AIR UNIT [Duct height]x[Duct weight]

RETURN AIR UNIT [Duct height]x[Duct weight]

EXHAUST AIR UNIT [Duct height]x[Duct weight]

RELIEF AIR UNIT [Duct height]x[Duct weight]

OUTDOOR AIR UNIT [Duct height]x[Duct weight]

MIXED AIR UNIT [Duct height]x[Duct weight]

PART 3 EXECUTION

3.01 INSTALLATION

- A. All ductwork shall be fabricated and erected where shown on the Drawings or as specified herein. Ductwork shall be rigidly supported and secured in an approved manner. Bracing and vibration isolators shall be installed, where necessary, to eliminate vibration, rattle and noise. Hangers shall be installed plumb and securely suspended from supplementary steel or inserts in concrete slabs. Lower ends of hanger rods shall be sufficiently threaded to allow for adequate vertical adjustment. Building siding and metal decking shall not be used to hang ductwork.
- B. The Contractor shall not install any equipment or materials until the Owner and Engineer have approved all submittals. If any equipment or materials are installed prior to approval of the submittals, it shall be at the Contractor's risk.
- C. Wherever ducts are divided, the cross-sectional area shall be maintained. All such changes must be approved and installed as directed by the Engineer or as approved on shop or erection drawings.
- D. During installation the open ends of ducts shall be closed to prevent debris and dirt from entering. Work shall be installed in accordance with the overall approved progress schedule and in cooperation with all other trades so there will be no delay to other trades.
- E. The unused portion of external louvers (where it is not as a fresh air intake or exhaust) shall be provided with a blank-off constructed of 0.0625-in. aluminum. Blank-off panels shall be provided with aluminum reinforcing angles to prevent buckling and secured to the exterior wall with aluminum angles and rustproof fasteners on not more than 12-in. centers. Caulking shall be provided completely around the outside edge of the angle and the aluminum.
- F. Install automatic dampers when supplied by other trades.
- G. The Drawings of the air ducts and air risers indicate the general location for installation of the ducts and risers. Should additional offsets or changes in direction be made, these changes must be considered in the original bid and shall be installed at no additional cost to the Owner.
- H. All necessary allowances and provisions shall be made in the installation of the ducts for the structural conditions of the building. Ducts shall be transformed or divided as may be required. Wherever this is necessary, the cross-sectional area shall be maintained. All of these changes, however, must be approved and ducts installed as directed by the Engineer or as approved on shop or erection drawings.
- I. The taper of all transformations shall be not more than 15 degrees.
- J. Do not remove or alter factory installed duct reinforcing ribs except as required to accommodate duct alterations due to unexpected field conditions. Notify the Owners representative prior to starting any field modifications involving ductwork structural reinforcing members. Submit additional design calculations to demonstrate structural design integrity of ductwork and fittings requiring reinforcing modifications in the field.

- K. No ductwork or components shall be shipped prior to complete resin cure.
- L. Ductwork connections to units that require corrosion resistant coatings shall be made with flanges. Flanges shall be factory drilled before coating. Resilient washers suitable for the environment shall be used to protect the coating from the bolts in the flange. The use of self-tapping screws or other fastening methods that will damage the coating are not acceptable.

3.02 HANGERS

- A. Rectangular Ductwork, Round and Flat-Oval Ductwork - Spacing and size of hangers shall be as required by the ductwork manufacturer. Ductwork support systems shall include restraints as required by the applicable building codes to withstand seismic loading. Design shall be provided by a professional engineer hired by the Contractor as specified in other sections of the specification.
- B. All hanger materials shall be Type 316 stainless steel.
- C. Perforated band iron or wire for supporting ducts will not be permitted. Ducts shall not be supported from furring, hung ceilings or from another duct or pipe.
- D. C-clamp type hangers shall be supplied with a retainer strap.
- E. Ductwork shall not come in contact with any of the ceiling construction or any other equipment in the ceiling cavity.
- F. Fiberglass ductwork shall be properly anchored and supported from building structure where indicated on the Drawings. Support anchoring for horizontal ducts shall be 15-ft.-0-in. on center, maximum spacing. Each anchor shall consist of two semi-circular stainless steel bands around the duct bolted together vertically and horizontally. The structural supports or wall securement shall be stainless steel and furnished and installed under this Section.
- G. All fittings expansion joints and similar items shall be supported within 18-in. of the joint unless otherwise noted.
- H. Hanger system shall use threaded rod for adjustability for ductwork over 24-in. in diameter or width.
- I. The following methods of hanger attachment to the building structure are NOT allowed. The numbers and letters refer to hanger methods shown in Figures 4-1, 4-2, and 4-3 of the 1985 edition of the HVAC Duct Construction Standards Metal and Flexible as published by SMACNA.
 - 1. "T" - wrap around strap on open web joist.
 - 2. "W" - bent over band on open web joist.
 - 3. "14" - friction clamps.
 - 4. "17" - bent wire in metal deck.

- J. Design of hangers shall include the effect of all loads applied to the duct as well as the load of the duct. These loads include, but are not limited to wind, snow seismic and internal dirt or liquid buildup.
- K. Hangers shall not be supported from roof decking or bulb tees. Where required, provide supplemental steel to span between the building structures.

3.03 DUCTWORK FITTINGS AND ACCESSORY ITEMS

- A. Duct Elbows - Changes in direction and offsets shall be made in a gradual manner to facilitate streamline flow of air. All elbows shall have a centerline radius of not less than 1-1/2 times the width of the duct in the plane of the elbow. For rectangular ductwork where full radius elbows cannot be installed or abrupt elbows are shown, provide abrupt elbows equipped with shop-installed hollow, fiberglass air foil turning vanes. An access door shall be installed at each abrupt elbow, so located for easy access to turning vanes.
- B. Dampers
 - 1. Manual volume control dampers shall be installed wherever it may be necessary to regulate air volume for system air balancing and where shown on the Drawings. Dampers shall be standard butterfly or parallel blade type on channel frame with external damper position indicator, manual adjustment and position locking arrangement.
 - 2. An access door, of ample size to permit maintenance and resetting of damper blades, shall be installed at each damper, so located for easy access to the damper blades.
- C. Access Doors
 - 1. Hinged access doors shall be installed where listed below, wherever shown on the Drawings and wherever access may be required for service, maintenance and adjustment. Access doors shall be 24-in. by 24-in. minimum, except where the duct size is less than 26-in., where the largest door that will fit the duct will be used. Unhinged access panels are not acceptable, except where so specified on the Drawings. Access doors shall be of the same material as the duct. Doors shall be substantially butt hinged, with heavy sash locks and substantial door pulls. Door openings and door frames shall be reinforced with bar stock or angle. Access doors may be factory fabricated. Access door hardware shall be Type 316 stainless steel.
 - 2. Provide access doors at the following locations (minimum requirements):
 - a. Automatic dampers - linkage side.
 - b. Duct mounted temperature controllers.
 - c. Freeze-stats.
 - d. Manual balancing dampers.
 - e. Turning vanes.
 - f. Fire dampers.
 - g. Smoke dampers.
 - h. Inlet side of centrifugal fans.
 - i. Inlet and outlet sides of tubular axial-flow fans.
 - j. As necessary or required.

3. Where access doors are required in ductwork located above ceilings the location of the access doors shall be coordinated to clear the ceiling support system and to be accessible through the ceiling grid.

3.04 FILLING IN SPACE AROUND DUCTS

- A. To prevent sound passing through the area between the duct and the framed or cut opening in the floors, walls or partitions, mineral wool shall be packed to completely fill the space the full depth of the opening. Whenever a fire-rated wall or floor is penetrated the space around the duct shall be filled with a locally approved type of fireproof rope.
- B. At fire walls, apply Type 316 stainless steel sheet metal escutcheon plates on both faces of the wall in order to close the gap between the structure and the sides of the insulated or bare duct.

3.05 DUCT SUPPORTS THROUGH FLOORS

- A. Where vertical ducts pass through floor openings, supporting angles shall be rigidly attached to the ducts and anchored with expansion bolts to the floor or curb. Angles shall be Type 316 stainless steel placed on the two long sides of the duct extending 3-in. over edge of opening.
- B. Remaining open area in the floor opening shall be sealed with a Type 316 stainless steel plate.

3.06 SUPPORTING OUTDOOR DUCTS

- A. The ducts installed above roof shall be provided with angle iron supports. Sizes of angles shall be as shown on the Drawings.
- B. The vertical supporting angles shall be continuous full height of the duct and shall be bolted to same. These, together with intermediate supporting angle as required, shall be provided with bottom plates which shall be welded to the vertical angles. The plates shall be attached with anchor bolts to sleepers, which shall be placed on scraped roofing. All of these angles shall be welded together in order to form a stiff continuous supporting unit for the duct. Angles shall be painted with oxide primer after installation.
- C. Ducts shall be sloped to shed water.

3.07 DUCTWORK AT MASONRY

- A. Where ducts connect to or terminate at masonry openings or along the edges of floors where concrete curbs are not being provided, there shall be placed around the ductwork a continuous 2-1/2-in. by 2-1/2-in. by 3/16-in. angle of the same material as the duct which shall be bolted to the construction and made air tight to same by applying caulking compound on the angle before it is drawn down tight to construction.
- B. Plenums connected to concrete curbs shall be fastened with 3-in. by 3-in. by 1/4-in. thick continuous angle of the same material as the duct. Concrete curbs will be provided under another Division. This angle shall sit on a continuous bead of caulking compound and be anchored to the curb at 16-in. centers. The duct shall terminate at the curb and be fastened to the angle. A continuous bead of caulking compound shall seal the plenum to the curb.

- C. When exposed ducts pass through finished floors, walls or ceilings, provide angle collars completely covering space around duct.

3.08 QUALITY

- A. All ductwork shall be free from pulsation, chatter, vibration or objectionable noise. After system is in operation, should these defects appear they shall be corrected by removing, replacing or reinforcing the work. Sound levels shall not exceed the minimum requirement as specified in ASHRAE - Systems Volume. No discreet tones will be allowed.
- B. The maximum allowable leakage of low pressure system shall be 5 percent of air volume.
- C. The maximum allowable leakage of high pressure systems shall be one percent of air volume when tested at 100 percent of the operating static pressure.
- D. The Engineer reserves the right to reject acceptance of delivery of any or all pieces of equipment found upon inspection to have any or all of the following defects in the laminate:
 - 1. Blisters
 - 2. Chips
 - 3. Crazing
 - 4. Exposed glass
 - 5. Cracks
 - 6. Burned areas
 - 7. Dry spots
 - 8. Foreign matter
 - 9. Surface porosity
 - 10. Sharp discontinuity
 - 11. Trapped air
 - 12. Any item which does not satisfy the tolerances as specified.

3.09 CLEANING OF DUCTWORK

- A. All ductwork, fans, outlets, and other parts of the ductwork systems shall be maintained in a clean condition during installation.
- B. Complete ductwork systems shall be cleaned prior to testing and air balancing. Cheese cloth shall be secured over all openings of the ductwork system for entrapment of dirt during the cleaning operation.

3.10 PAINTING

- A. Louver blank-off panels and ductwork visible through louvers in exterior walls are to be painted black. Painting shall be performed under this Section and shall be as specified in Division 9.

3.11 PLENUMS

- A. Fresh air inlet and exhaust air plenums at louvers or otherwise subject to weather entrainment shall be sealed water tight at all bottom joints and seams and up all vertical seams for a minimum of 12-in. After application excess sealant shall be removed before setting hard. Where possible fresh air inlet and exhaust air plenums shall pitch down towards the louver. Where it is not possible to pitch the plenum a 1-in. capped drain connection shall be provided at the low point of the plenum.

3.12 TEST PORTS

- A. Where shown on the Drawings and where required for testing and balancing, instrument insertion ports shall be provided. Size and location of ports shall be coordinated with the contractor performing air balancing. Ports shall be sealed with plastic snap lock plugs. When the ductwork will be insulated the port shall be extended to the face of the insulation and the vapor barrier sealed to the port.
- B. In round ductwork provide two ports 90 degrees on centers. In rectangular ductwork, provide ports as required by AABC or NEBB for a full traverse measurement.
- C. As a minimum, ports shall be provided in the following connections:
 - 1. All duct mains.
 - 2. All duct branches unless all connections are diffusers, registers, or grilles and the total can be calculated by summing the readings for all of the connections.
 - 3. All connections to tanks or hoods where there is no other access for taking a measurement.
- D. A main duct is defined as one of the following:
 - 1. A duct serving five or more outlets.
 - 2. A duct serving two or more branch ducts.
 - 3. A duct emanating from a fan or plenum.
 - 4. All remaining ducts are considered branch ducts.

END OF SECTION

SECTION 15950
TESTING, ADJUSTING, AND BALANCING

PART 1 GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Balancing Air Systems:
 - a. Constant-volume air systems.

1.02 DEFINITIONS

- A. AABC: Associated Air Balance Council.
- B. NEBB: National Environmental Balancing Bureau.
- C. TAB: Testing, adjusting, and balancing.
- D. TABB: Testing, Adjusting, and Balancing Bureau.
- E. TAB Specialist: An entity engaged to perform TAB Work.

1.03 SUBMITTALS

- A. Strategies and Procedures Plan: Within 30 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.
- B. Certified TAB reports.

1.04 QUALITY ASSURANCE

- A. TAB Contractor Qualifications: Engage a TAB entity certified by AABC, NEBB or TABB.
 - 1. TAB Field Supervisor: Employee of the TAB contractor and certified by AABC, NEBB or TABB.
 - 2. TAB Technician: Employee of the TAB contractor and who is certified by AABC, NEBB or TABB as a TAB technician.
- B. Certify TAB field data reports and perform the following:
 - 1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
 - 2. Certify that the TAB team complied with the approved TAB plan and the procedures specified and referenced in this Specification.
- C. TAB Report Forms: Use standard TAB contractor's forms.

- D. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE 111, Section 5, "Instrumentation."
- E. TAB SUBCONTRACTOR SHALL BE HIRED, DIRECTED AND PAID BY THE GENERAL CONTRACTOR, INDEPENDENT OF THE MECHANICAL CONTRACTOR.
- F. Acceptable TAB subcontractors:
 - 1. PHI
 - 2. Air Technologies
 - 3. Fluid Balance, Inc.

PART 2 PRODUCTS (NOT APPLICABLE)

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.
- B. Examine systems for installed balancing devices, such as manual volume dampers. Verify that locations of these balancing devices are accessible.
- C. Examine the approved submittals for HVAC systems and equipment.
- D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.
- E. Examine ceiling plenums used for supply, return, or relief air to verify that they meet the leakage class of connected ducts as specified in Division 15 Section "Metal Ducts" and are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.
- F. Examine equipment performance data including fan curves.
 - 1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
 - 2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

- G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.
- H. Examine test reports specified in individual system and equipment Sections.
- I. Examine HVAC equipment and filters and verify that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.
- J. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- K. Examine operating safety interlocks and controls on HVAC equipment.
- L. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.
- M. Perform duct leak testing of all duct systems. Coordinate testing with Commissioning Agent and Engineer. Leakage shall be less than 6 CFM per SF of conditioned floor area served by the unit, at 25 Pa test pressure, or as required by latest code and ordinance.

3.02 PREPARATION

- A. Prepare a TAB plan that includes strategies and step-by-step procedures.
- B. Complete system-readiness checks and prepare reports. Verify the following:
 - 1. Permanent electrical-power wiring is complete.
 - 2. Automatic temperature-control systems are operational.
 - 3. Equipment and duct access doors are securely closed.
 - 4. Balance, smoke, and fire dampers are open.
 - 5. Isolating and balancing valves are open.
 - 6. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
 - 7. Windows and doors can be closed so indicated conditions for system operations can be met.
- C. TAB Subcontractor shall visit the site not less than twice during the duct installation, prior to insulation, to verify balancing devices are being installed in proper locations and functional for balancing efforts. Submit a written report at each visit as to what was found, and any recommendations, and to verify corrections were or were not made from previous visits.
- D. Coordinate with the Mechanical Contractor to participate in a complete duct leakage test for the supply and return duct.

3.03 GENERAL PROCEDURES FOR TESTING AND BALANCING

- A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance" or ASHRAE 111 or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" or SMAC-NA's "HVAC Systems - Testing, Adjusting, and Balancing" and in this Section.
 - 1. Comply with requirements in ASHRAE 62.1-2004, Section 7.2.2, "Air Balancing."
- B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.
 - 1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
 - 2. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Division 15 Section "HVAC Insulation."
- C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.
- D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.04 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

- A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.
- B. Prepare schematic diagrams of systems' "as-built" duct layouts.
- C. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.
- D. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.
- E. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- F. Verify that motor starters are equipped with properly sized thermal protection.
- G. Check dampers for proper position to achieve desired airflow path.
- H. Check for airflow blockages.
- I. Check condensate drains for proper connections and functioning.
- J. Check for proper sealing of air-handling-unit components.
- K. Verify that air duct system is sealed as specified in Division 15 Section "Metal Ducts."

3.05 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

- A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
 - 1. Measure total airflow.
 - a. Where sufficient space in ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow.
 - 2. Measure fan static pressures as follows to determine actual static pressure:
 - a. Measure outlet static pressure as far downstream from the fan as practical and upstream from restrictions in ducts such as elbows and transitions.
 - b. Measure static pressure directly at the fan outlet or through the flexible connection.
 - c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from the flexible connection, and downstream from duct restrictions.
 - 3. Measure static pressure across each component that makes up an air-handling unit.
 - a. Report the cleanliness status of filters and the time static pressures are measured.
 - 4. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
 - 5. Comply with requirements in Division 15 Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
 - 6. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.
- B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.
 - 1. Measure airflow of submain and branch ducts.
 - a. Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.
 - 2. Measure static pressure at a point downstream from the balancing damper, and adjust volume dampers until the proper static pressure is achieved.
 - 3. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.
- C. Measure air outlets and inlets without making adjustments.

1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.
- D. Adjust air outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using branch volume dampers rather than extractors and the dampers at air terminals.
 1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
 2. Adjust patterns of adjustable outlets for proper distribution without drafts.

3.06 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

- A. Compensating for Diversity: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a minimum set-point airflow with the remainder at maximum airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced-airflow terminal units so they are distributed evenly among the branch ducts.
- B. Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
 1. Set outdoor-air dampers at minimum, and set return- and exhaust-air dampers at a position that simulates full-cooling load.
 2. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
 3. Measure total system airflow. Adjust to within indicated airflow.
 4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
 5. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow the same as described for constant-volume air systems.
 - a. If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.
 6. Remeasure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
 - a. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.

7. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit.
 8. Record final fan-performance data.
- C. Pressure-Dependent, Variable-Air-Volume Systems without Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
1. Balance variable-air-volume systems the same as described for constant-volume air systems.
 2. Set terminal units and supply fan at full-airflow condition.
 3. Adjust inlet dampers of each terminal unit to indicated airflow and verify operation of the static-pressure controller. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
 4. Readjust fan airflow for final maximum readings.
 5. Measure operating static pressure at the sensor that controls the supply fan if one is installed, and verify operation of the static-pressure controller.
 6. Set supply fan at minimum airflow if minimum airflow is indicated. Measure static pressure to verify that it is being maintained by the controller.
 7. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow the same as described for constant-volume air systems.
 - a. If air outlets are out of balance at minimum airflow, report the condition but leave the outlets balanced for maximum airflow.
 8. Measure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
 - a. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.
- D. Pressure-Dependent, Variable-Air-Volume Systems with Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
1. Set system at maximum indicated airflow by setting the required number of terminal units at minimum airflow. Select the reduced-airflow terminal units so they are distributed evenly among the branch ducts.
 2. Adjust supply fan to maximum indicated airflow with the variable-airflow controller set at maximum airflow.
 3. Set terminal units at full-airflow condition.

4. Adjust terminal units starting at the supply-fan end of the system and continuing progressively to the end of the system. Adjust inlet dampers of each terminal unit to indicated airflow. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
5. Adjust terminal units for minimum airflow.
6. Measure static pressure at the sensor.
7. Measure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.

3.07 PROCEDURES FOR MOTORS

- A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:
 1. Manufacturer's name, model number, and serial number.
 2. Motor horsepower rating.
 3. Motor rpm.
 4. Efficiency rating.
 5. Nameplate and measured voltage, each phase.
 6. Nameplate and measured amperage, each phase.
 7. Starter thermal-protection-element rating.
- B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass of the controller to prove proper operation. Record observations including name of controller manufacturer, model number, serial number, and nameplate data.

3.08 PROCEDURES FOR CONDENSING UNITS

- A. Verify proper rotation of fans.
- B. Measure entering- and leaving-air temperatures.
- C. Record compressor data.

3.09 PROCEDURES FOR HEAT-TRANSFER COILS

- A. Measure, adjust, and record the following data for each electric heating coil:
 1. Nameplate data.

2. Airflow.
3. Entering- and leaving-air temperature at full load.
4. Voltage and amperage input of each phase at full load and at each incremental stage.
5. Calculated kilowatt at full load.
6. Fuse or circuit-breaker rating for overload protection.

B. Measure, adjust, and record the following data for each refrigerant coil:

1. Dry-bulb temperature of entering and leaving air.
2. Wet-bulb temperature of entering and leaving air.
3. Airflow.
4. Air pressure drop.
5. Refrigerant suction pressure and temperature.

3.10 TOLERANCES

A. Set HVAC system's air flow rates and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
2. Air Outlets and Inlets: Plus or minus 10 percent.
3. Odorous Exhaust Systems (plus/minus 5 percent).

3.11 REPORTING

- A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

3.12 FINAL REPORT

- A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.

1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
2. Include a list of instruments used for procedures, along with proof of calibration.

- B. Final Report Contents: In addition to certified field-report data, include the following:

1. Pump curves.
 2. Fan curves.
 3. Manufacturers' test data.
 4. Field test reports prepared by system and equipment installers.
 5. Other information relative to equipment performance; do not include Shop Drawings and product data.
- C. General Report Data: In addition to form titles and entries, include the following data:
1. Title page.
 2. Name and address of the TAB contractor.
 3. Project name.
 4. Project location.
 5. Architect's name and address.
 6. Engineer's name and address.
 7. Contractor's name and address.
 8. Report date.
 9. Signature of TAB supervisor who certifies the report.
 10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
 11. Summary of contents including the following:
 - a. Indicated versus final performance.
 - b. Notable characteristics of systems.
 - c. Description of system operation sequence if it varies from the Contract Documents.
 12. Nomenclature sheets for each item of equipment.
 13. Data for terminal units, including manufacturer's name, type, size, and fittings.
 14. Notes to explain why certain final data in the body of reports vary from indicated values.
 15. Test conditions for fans and pump performance forms including the following:
 - a. Settings for outdoor-, return-, and exhaust-air dampers.
 - b. Conditions of filters.
 - c. Cooling coil, wet- and dry-bulb conditions.
 - d. Face and bypass damper settings at coils.

- e. Fan drive settings including settings and percentage of maximum pitch diameter.
 - f. Inlet vane settings for variable-air-volume systems.
 - g. Settings for supply-air, static-pressure controller.
 - h. Other system operating conditions that affect performance.
- D. System Diagrams: Include schematic layouts of air distribution systems. Present each system with single-line diagram and include the following:
- 1. Quantities of outdoor, supply, return, and exhaust airflows.
 - 2. Duct, outlet, and inlet sizes.

3.13 ADDITIONAL TESTS

- A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.
- B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION

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SECTION 16150
RACEWAYS, FITTINGS AND SUPPORTS

PART 1 GENERAL

1.01 SUMMARY

- A. This section specifies raceways, fittings, and supports for all cables, conductors and electrical equipment. The Contractor shall furnish and install complete raceway systems in accordance with the following specifications and as also shown on the PLANS.
- B. The subsequent document entitled "Appendix A – Conduit/wire Schedule" is hereto made part of this section and includes a listing of proposed raceways and other requirements. This schedule in "Appendix A" is not inclusive of all equipment required by this Contract. Refer to Part 2 of this section for additional requirements in addition to those listed in "Appendix A".

1.02 RELATED REQUIREMENTS

- A. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
- B. It is the CONTRACTOR's responsibility for scheduling and coordinating the Work of subcontractors, Suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR's Work.
- C. Related work as called for on the PLANS, as specified herein or in other Sections of the Specifications..

1.03 REFERENCES

- A. The publications listed below form a part of this specification to the extent referenced. The Publications are references in the text by designation only.
- B. This section contains references to codes and standards. They are a part of this section as specified. In case of conflict between the requirements of this section and the listed standards, the requirements of this section shall prevail. All raceways, fitting and supports are to be U.L. listed and certified and shall conform to ANSI and NEMA standards.

1.04 SUBMITTALS

- A. The Contractor shall submit manufacturer's catalog data for all material provided under this section and in accordance with the requirements of Section 01300 and 01730 of the Specifications. The Contractor shall submit certified notification from the Manufacturer that the rigid aluminum conduit system and all related materials, as described within this specification, is 99.0 percent copper-free.
 - 1. Submit certifications of training associated with proper installation the PVC coated rigid galvanized conduit.
 - 2. Material Safety Data sheets for all sealants, solvents, etc.

PART 2 PRODUCT

2.01 EXPOSED CONDUIT SYSTEM INDOOR, AND EXPOSED-OUTDOOR ABOVE GROUND LEVEL

- A. General: All components shall be 99.0 percent copper free rigid aluminum.
- B. Rigid Metal Conduit System
 - 1. Conduit run above ground shall be rigid aluminum in all areas unless specifically specified otherwise hereinafter in subsection 3.02, this Section of the Specifications.
 - 2. Rigid Aluminum Conduit shall meet the following requirements
 - a. U.L. listed
 - b. Comply with ANSI C80.5 and U.L.6.
 - 3. Bending Requirements: Furnish factory bends. 90-degree bends of conduit sizes equal to or greater than 4-inches in diameter shall have a minimum bending radius of 48-inches unless otherwise noted on the PLANS. 90-degree factory bends of conduit sizes less than 4-inches in diameter, shall be per manufacturers standard unless otherwise noted on the PLANS.
 - 4. Minimum conduit size for all work shall be 3/4 inches.
 - 5. Manufacturer: VAW of America Inc., or approved equal.
- C. Conduit Hubs:
 - 1. Provide grounding type with integral threaded insulated throat, and with solderless grounding lugs, complete with rubber gasket.
 - 2. Manufacturer: by "Myers", or approved equal.
- D. Grounding Bushings:
 - 1. Provide with integral threaded insulated throat, and with solderless grounding lugs
 - 2. Manufacturer: "O.Z. Gedney" type ABLG with specified options, or approved equal.
- E. Conduit Bodies
 - 1. Conduit body covers shall be of the Die Cast Aluminum bolt-on type and shall have Type 316-Stainless Steel screws/hardware.
 - 2. Each conduit body cover shall be supplied with a separate gasket.
 - 3. Manufacturer: "Crouse-Hinds" Form-7, or approved equal.
- F. Conduit Unions: Threaded, as manufactured by "Crouse-Hinds" type UNF or UNY, or approved equal

G. Conduit Reducers:

1. Threaded Aluminum.
2. Shall be used for final conduit system connection to equipment where shown on the PLANS
3. Manufacturer: "Crouse-Hinds" type RE and type REA, or approved equal.

H. Cord and Cable Fittings:

1. Provide threaded gland nut, straight threaded body, and also a neoprene sealing cable bushing.
2. Furnished with a Type 316 Stainless Steel wire mesh grip
3. Shall be used only where specifically shown on the PLANS.
4. Manufacturer: "Crouse-Hinds" type CGB, complete with all specified accessories, or approved equal.

I. Expansion Fittings:

1. Furnished with oversized sleeve and insulated bushing
2. Furnished with tinned copper braided bonding jumper
3. Manufacturer: 3M 2123, or approved equal

J. Sealing Fittings:

1. Furnish with drain
2. Manufacturer: Crouse Hinds, Type EYD, or approved equal
3. Sealing Compound:
 - a. Where conduit seals are installed in compliance with NEC Class-I and Class-II requirements, the sealing compound shall be as manufactured by "Crouse-Hinds" type Chico-AP, or approved equal.
 - b. Where conduit seals are not required for NEC Class-I and Class-II installations but are shown to be installed on the PLANS to block the migration of corrosive gases into the conduit system and conduit bodies, the conduit seals Sealing Compound shall be as manufactured by "3M" type Scotchcast Reenterable Electrical Insulating Resin 2123, or approved equal.

K. Miscellaneous Requirements:

1. Conduit nipples shall have two independent sets of threads.

2.02 UNDERGROUND CONDUIT IN DUCT BANK SYSTEM

A. General:

1. Type: All components shall be non-metallic, except where noted herein and specifically shown otherwise on the PLANS. Refer to the PLANS.
2. Bending Requirements: Furnish factory bends. 90-degree factory bends of conduit sizes equal to or greater than 4-inches in diameter shall have a minimum bending radius of 48-inches. Also, all 90-degree, 45-degree, and 30-degree conduit bends shall be factory made bends.
3. Minimum conduit size for all work shall be 1 inch.

B. Rigid Nonmetallic Conduit System

1. All components shall be schedule 40 PVC, heavy wall, U.L. rated, No. 651, conforming to NEMA standard TC-2-75 and listed in conformity with Article 352 of the latest edition of the National Electrical Code (NEC).
2. Solvent weld: Shall be a type approved by the conduit manufacturer.
3. Manufacturer: Conduit shall be as manufactured by "Carlton", or approved equal.

C. PVC Coated Rigid Galvanized Steel Conduit System

1. Material: Steel per UL 6 and ANSI C80.1, hot-dipped galvanized inside and out after the threads are cut.
2. Exterior Coatings:
 - a. After galvanizing, the conduit/fittings shall be uniformly and consistently coated with a gray PVC coating of minimal 40 mil thickness. Exception: The threads shall be coated with urethane in lieu of PVC.
 - b. The PVC coating adhesion performance shall be ETL verified to the Intertek ETL SEMKO, High Temperature H₂O PVC Coating Adhesion, Test Procedure for 200 hours.
3. Interior Coating:
 - a. After galvanizing, the interior of conduit and fittings shall be uniformly and consistently coated with a urethane coating of nominal 2 mil thickness.
4. Accessories: Threads shall be furnished with plastic thread protector caps.
5. Manufacturer: Robroy Industries, Perma-Cote, Plasti-Bond REDH₂OT, or approved equal.

2.03 LIQUID TIGHT FLEXIBLE CONDUIT

- A. Sizes: - Greater than or equal to $\frac{3}{4}$ inch and smaller than or equal to 2 inch Flexible Conduit:
 - 1. Conduit Type: Non-metallic type liquid tight conduit, formed from PVC plastic
 - 2. Conduit Installation Temperature Range: -20 degrees Celsius to $+60$ degrees Celsius (suitable for use outdoors and indoors)
 - 3. Conduit Manufacturer: ELECTRI-FLEX series NM type B-PVC, or approved equal.
 - 4. Fittings Type: Non-metallic PVC fittings
 - 5. Fittings Manufacturer: CARFLEX, or approved equal.
- B. Sizes:- Greater than 2 inch Flexible Conduit:
 - 1. Conduit Type: PVC-COATED metallic (aluminum core) liquid tight conduit, formed from PVC plastic
 - 2. Conduit Temperature Range: -20 degrees Celsius to $+60$ degrees Celsius (suitable for use outdoors and indoors)
 - 3. Conduit Manufacturer: SEALTITE, or approved equal.
 - 4. Fittings Type: 99.0 percent Copper-Free-Aluminum
 - 5. Fittings Manufacturer: Appleton, Crouse-Hinds, or approved equal.
- C. Minimum liquid-tight flexible conduit size for all work shall be $\frac{3}{4}$ -inch unless specifically noted otherwise on the PLANS. Exception: $\frac{1}{2}$ " non-metallic may be used on device with $\frac{1}{2}$ " threaded opening with prior owner approval.

2.04 MISCELLANEOUS

- A. Fire-retardant and waterproof conduit/duct sealant: NELSON FLAMESEAL, or approved equal,
- B. Pipe Tape: 20 mil, 3M company No.51, or approved equal
- C. Conduit Sleeves
 - 1. Conduit sleeves shall be schedule 80 PVC, heavy wall, U.L. rated, No. 651, conforming to NEMA standard TC-2-75 and listed in conformity with Article 352 of the National Electrical Code (NEC).

2.05 ELECTRICAL EQUIPMENT AND RACEWAY SYSTEM SUPPORT CHANNELS

- A. General requirements for all support channels:
 - 1. Channels located in all areas:
 - a. Type: Type 316-Stainless Steel

- b. Manufacturer: “Unistrut Corporation” series P-1000ST and P-1001ST, or approved equal.
- B. All fastening hardware, fittings, supports, post bases, conduit clamps, beam clamps channel nuts, threaded rod, framing system, etc. shall be as follows:
- 1. Items located in all areas:
 - a. Type 316 stainless steel
 - 2. Manufacturer: “Unistrut Corporation”, or approved equal.
 - 3. Additionally, the following designations correspond to the following “Unistrut Corporation” series numbers as used in the details shown on the PLANS:
 - a. Items located in all areas:
 - 1) Beam clamps: “Unistrut Corporation” series P-2785ST and P-2786ST, or approved equal.
 - 2) Swivel fittings: “Unistrut Corporation” series M-2137ST, or approved equal.
 - 3) Post bases: “Unistrut Corporation” series P-2072AST and series P-2073AST, or approved equal.
 - 4) Hanger clevis fittings: “Unistrut Corporation” series P-2682ST, or approved equal.
- C. Expansion anchors shall be installed per the manufacturer’s recommendations and shall be as follows:
- 1. Expansion anchors located in all areas:
 - a. Type 316-Stainless Steel. Expansion anchors shall also be per Section 05120 “Structural Steel”. Epoxy inserts are not allowed.
 - 2. Also refer to the PLANS.

2.06 MANHOLES AND HANDHOLES

- A. Refer to the Civil/Structural PLANS and Specifications for manhole requirements.
- B. Furnish and install handholes as shown on the PLANS and as specified herein.
- C. Provide all cable pulling eyes, cable support system components and accessories indicated on the PLANS and as otherwise required. Arrange support systems so that each cable can be securely anchored.

2.07 CABLE SUPPORT SYSTEM IN UNDERGROUND ELECTRICAL MANHOLES AND HANDHOLES

- A. General Requirements for support channels:
 - 1. Type: Type 316-Stainless Steel
 - 2. Manufacturer: “Unistrut Corporation” series P-1000ST and P-1001ST, or approved equal.

- B. All fastening hardware, fittings, supports, post bases, conduit clamps, beam clamps channel nuts, threaded rod, framing system, etc. shall be fabricated with Type 316 stainless steel, as manufactured by “Unistrut Corporation”, or approved equal. Additionally, the following designations correspond to the following “Unistrut Corporation” series numbers as used in the details shown on the PLANS:
1. Porcelain Clamps and Saddles-“Unistrut Corporation P1787A through P1795B Porcelain Cable Clamps”, for both Electric and Communications and Instrumentation and Control.
 2. Surface Mounted Vertical Channels (Columns)-“Unistrut P-1000ST Type 316 stainless steel channels and accompanying Unistrut post bases”.
 3. Surface Mounted Horizontal Channels (side mounted channels)-“Unistrut P-1001ST Type 316 stainless steel channels and accompanying Unistrut post bases as well as wall mounted vertical channels”.
 4. Brackets-“Unistrut” P-2515 ST of 15 inch length for Electric, and P-2542 ST of 15 inch length for Telephone and Communications. All parts given shall be Type 316 stainless steel.
 5. Beam Clamps – “Unistrut” P-2785 ST”. All parts given shall be Type 316 stainless steel.

PART 3 EXECUTION

3.01 GENERAL

- A. Install electrical equipment and conduit raceway system in accordance with the recommendations of the manufacturer, the requirements of the latest edition of the National Electrical Code, and the PLANS. All cables/wiring shall be installed in a raceway system.
- B. Contractor shall be trained and certified by the PVC coated rigid galvanized steel conduit manufacturer in the proper installation of the PVC coated rigid galvanized conduit.

3.02 CONDUIT SYSTEM

A. General:

1. Run conduits continuous from outlet to outlet, from outlets to cabinets, pull or junction boxes, etc..
2. Install all conduits as a complete system before wiring is pulled in. Conduits shall be reamed, thoroughly cleaned of debris, and swabbed immediately before wire is pulled.
3. Furnish and install expansion fitting for each conduit across structural expansion joints. Coordinate locations of expansion joints with the PLANS. Additionally, furnish and install additional appropriate fittings such as conduit unions, adapters, etc. as required for a complete installation.
4. Conduit shall contain no more than the equivalent of three (3) 90 degree bends between outlets or pull points.

5. Maintain a minimum 6 inch clearance between conduit and piping and a minimum 12 inch clearance between conduit and heat sources.
 6. Protect all coated conduit from accidental coating damage during storage and installation. Repair all damaged conduits in accordance with manufacturer's recommendations at no additional cost to the OWNER.
 7. Furnish and install temporary conduit closures during construction activities to prevent foreign matter from entering raceways.
 8. Furnish and install conduit measuring tape in each empty spare conduit as manufactured by Ideal Industries Incorporated or approved equal.
- B. Additional requirements regarding the use of the Owner's existing conduit system:
1. Prior to the installation of wiring in the OWNER's existing conduits, thoroughly clear existing conduits that shall be used for renovation activity to remove 100 percent of obstructions (objects, rocks, concrete bits, rough edges, debris, etc.) that may damage the proposed wiring during the wire installation process. Field verify that the proposed wiring can be installed in the OWNER's existing conduits prior to attempting wire installation. Should it be discovered that the OWNER's existing conduits cannot be used without causing damage to the proposed wiring, the existing discovered field conditions must be brought to the OWNER's attention for execution of the necessary adjustments/modifications.
- C. Exposed Conduit System Indoor, and Exposed-Outdoor Above Ground Level:
1. Rigid conduit joints shall be cut square, threaded, reamed smooth and drawn up tight. Make field bends or offsets with an approved bender or hickey or hub type conduit fittings.
 2. Run conduit parallel or at right angles to building lines and such to avoid moisture traps.
 3. Arrange conduits to maintain headroom and present a neat appearance.
 4. Support conduit using support channels as shown on the PLANS and as specified herein.
 5. Coat all conduit threads with Penetrox or Noalox prior to assembly.
 6. Secure conduit runs firmly to specified support channels by conduit straps or by hangers, as required, and as shown on the PLANS.
- D. Underground Conduit in Duct Bank System
1. Install all underground conduit in concrete encased and steel reinforced duct banks.
 2. Concrete shall be Class 'A' per Section 403S "Concrete for Structures". A red admixture shall be added to the concrete a rate of 12 pounds per cubic yard of concrete and per the requirements of Section 403S. Red admixture shall meet the requirements of ASTM C-979-82. Red admixture shall be as manufactured by ChemSystems, Inc. series HBS #120 Conduit Red, or approved equal. Also, refer to conduit/duct bank reinforcement and concrete encasement details shown on the PLANS.

3. Provide a minimum of 3-inches separation between conduits installed in concrete construction except at panelboards, pull or junction boxes and/or other locations where the conduits are grouped. Furnish and install plastic spacers as shown on the PLANS.
4. Underground system conduits shall be installed with a minimum depth below finished grade of 24" to top of concrete envelope of duct bank and shall slope 3-inches per 100 feet from high points toward pull boxes and handholes/manholes, at minimum. Additionally, underground duct bank system shall be routed per the PLANS and coordinated with the depths of Civil/Structural foundations, beams, etc. No conduit shall be routed through grade beam slab of a building floor slab.
5. All underground conduit joints shall be watertight in accordance with the manufacturer's recommendations.
6. Transition from underground (underground work in duct bank) to above ground conduit as shown on the PLANS.
7. Where a duct bank penetrates a concrete structure, dowel between the duct bank and the structure at the point of penetration and tie the steel reinforcing rebar system of the underground duct bank system to the concrete structure and steel reinforcing rebar system of the concrete structure. Refer to the Civil/Structural Specifications and PLANS for additional requirements.

E. Conduit Penetrations:

1. Install sleeves for conduit penetrations of walls and floors unless shown otherwise on the PLANS. Install sleeves during erection of concrete and masonry walls. Exception: Sleeves are not required for conduits stub-ups through floor slab from underground duct bank. Sleeves are not required for cored penetrations in existing structures.
2. Where aluminum conduit penetrates a wall/floor-slab and/or walls/floors of dissimilar material (other than Stainless Steel) or is in contact with dissimilar material, wrap the aluminum conduit with Pipe Tape using a 50 percent overlap throughout the entire distance/length of the penetration and an additional 6-inches of distance beyond either side of the penetration/contacted region.
3. Install pitch pans on conduits which penetrate through roofs.
4. Also refer to the conduit penetration details shown on the PLANS.

F. Miscellaneous:

1. Seal empty spare conduits (at above ground stub-ups) with an aluminum screw in plug sized to the trade size (outer diameter) of the conduits.
2. Seal and pack/fill ends of each conduit with flame-retardant sealant.
3. In all sealing fittings, utilize sealing compound to seal around and between each conductor and associated sealing fitting body.

G. Requirements for cables inside of Manholes, Handholes, etc.:

1. Arrange cables so that there is a minimum of crossing. Provide slack in each cable.
2. Secure cables in handholes/manholes on support channel system as specified herein and as shown on the PLANS.

H. Connections to Equipment:

1. Liquid tight flexible conduit shall be used for connections to motors, field instruments, etc., and any equipment subject to vibration, and where shown on the PLANS. Length of conduit shall not exceed 30-inches, unless specifically noted otherwise on the PLANS or with prior approval of the Engineer/Owner.

3.03 INSTALLATION OF SUPPORT CHANNELS

- A. Utilize support channels and mounting hardware as previously specified to install raceways, and any other surface mounted electrical, instrumentation and control equipment. Refer to details shown on the PLANS.

3.04 HOUSEKEEPING CONCRETE PAD FOR EQUIPMENT

- A. Provide housekeeping concrete pad for all outdoor equipment whether it is free-standing or surface mounted. All housekeeping pad edges shall be chamfered. Outdoor electrical equipment pads shall be as detailed on the PLANS.
- B. Provide housekeeping concrete pad for indoor all free-standing equipment. Indoor electrical equipment pads shall be as detailed on the PLANS.

3.05 MEASUREMENT AND PAYMENT

- A. No separate measurement or payment for work performed under this Section. Include cost of same in Contract price bid for work of which this is a component part.

END OF SECTION

**APPENDIX A -
SOUTH AUSTIN REGIONAL WWTP GRAVITY THICKENER IMPROVEMENTS
CONDUIT WIRE SCHEDULE**

| PUMP BUILDING | | | | | |
|--------------------|------------|---|----------------|---------------------|---------------------------------------|
| CONDUIT TAG | TRADE SIZE | CABLE/WIRE DESCRIPTION | FROM | TO | ADDITIONAL REQUIREMENTS |
| STPB-AITGAS-I1 | 3/4" | 2 #16 2-CONDUCTOR TWISTED PAIR SHIELDED CABLE (I) | PULLBOX | GAS DETECTION PANEL | |
| STPB-AITGAS-I2 | 3/4" | 1 #16 2-CONDUCTOR TWISTED PAIR SHIELDED CABLE (I) | PB01-AE-14A1 | PULLBOX | |
| STPB-AITGAS-I3 | 3/4" | 1 #16 2-CONDUCTOR TWISTED PAIR SHIELDED CABLE (I) | PB01-AE-12A1 | PULLBOX | |
| STPB-ATS1-C | 3/4" | 4 #14 (C) 2 #14 (SP) 1 #10 (G) | STPB-ATS-001 | STPB-PBOX-RIO2A | |
| STPB-ATS1-EF | 3" | 3 500 kCMIL (P) 1 #2 (G) | MCC-SGT2 | STPB-ATS-001 | |
| STPB-ATS1-NF | 3" | 3 500 kCMIL (P) 1 #2 (G) | MCC-SGT1 | STPB-ATS-001 | |
| STPB-CP1-COMA | 2" | 1 TYPE I FIBER OPTIC CABLE(S) - 36 FIBER (COM) | PB01-CCP-01 | STPB-CP-001 | |
| STPB-CP1-COMB | 2" | 1 TYPE I FIBER OPTIC CABLE(S) - 36 FIBER (COM) | PB01-CCP-01 | STPB-CP-001 | |
| STPB-CPP-001-1 | 3/4" | 2 #10 (P) 1 #10 (G) | STPB-CPP-001 | RIO2A | |
| STPB-CPP-001-1,3,5 | 1" | 6 #10 (P) 3 #10 (G) | STPB-CPP-001 | RIO2A | |
| STPB-CPP-001-3 | 3/4" | 2 #10 (P) 1 #10 (G) | STPB-CPP-001 | RIO2A | WIRING INCLUDED IN CONDUIT WITH CKT 1 |
| STPB-CPP-001-5 | 3/4" | 2 #10 (P) 1 #10 (G) | STPB-CPP-001 | RIO2A | WIRING INCLUDED IN CONDUIT WITH CKT 1 |
| STPB-CPP1-F | 1-1/4" | 4 #4 (P) 1 #10 (G) 1 #2 (IG) | STPB-XFMR-CPP1 | STPB-CPP-001 | |
| STPB-FCSEF1-C1 | 3/4" | 6 #14 (C) 2 #14 (SP) 1 #10 (G) | STPB-FCS-EF1 | MCC-SGT1 | |
| STPB-FCSEF1-C2 | 3/4" | 2 #14 (C) 1 #10 (G) | THERMOSTAT | STPB-FCS-EF1 | |

PUMP BUILDING

| CONDUIT TAG | TRADE SIZE | CABLE/WIRE DESCRIPTION | FROM | TO | ADDITIONAL REQUIREMENTS |
|------------------|------------|---|---------------------|-----------------|-------------------------|
| STPB-FCSEF2-C1 | 3/4" | 6 #14 (C) 2 #14 (SP) 1 #10 (G) | STPB-FCS-EF2 | MCC-SGT2 | |
| STPB-FCSEF2-C2 | 3/4" | 2 #14 (C) 1 #10 (G) | THERMOSTAT | STPB-FCS-EF2 | |
| STPB-FCSTSLP2-C | 3/4" | 6 #14 (C) 2 #14 (SP) 1 #10 (G) | STPB-FCS-TSLP2 | STPB-PB-TSLP2 | |
| STPB-FCSTSLP4-C | 3/4" | 6 #14 (C) 2 #14 (SP) 1 #10 (G) | STPB-FCS-TSLP4 | STPB-PB-TSLP4 | |
| STPB-FCSTSLP5-C | 3/4" | 6 #14 (C) 2 #14 (SP) 1 #10 (G) | STPB-FCS-TSLP5 | STPB-PB-TSLP5 | |
| STPB-FCSTSLP6-C | 3/4" | 6 #14 (C) 2 #14 (SP) 1 #10 (G) | STPB-FCS-TSLP6 | STPB-PB-TSLP6 | |
| STPB-FE9201-I1 | 3/4" | 1 VENDOR CABLE (I) | STPB-FE-9201 | STPB-FIT-9201 | |
| STPB-FE9201-I2 | 3/4" | 1 VENDOR CABLE (I) | STPB-FE-9201 | STPB-FIT-9201 | |
| STPB-FE9202-I1 | 3/4" | 1 VENDOR CABLE (I) | STPB-FE-9202 | STPB-FIT-9202 | |
| STPB-FE9202-I2 | 3/4" | 1 VENDOR CABLE (I) | STPB-FE-9202 | STPB-FIT-9202 | |
| STPB-FE9302-I1 | 3/4" | 1 VENDOR CABLE (I) | STPB-FE-9302 | STPB-FIT-9302 | |
| STPB-FE9302-I2 | 3/4" | 1 VENDOR CABLE (I) | STPB-FE-9302 | STPB-FIT-9302 | |
| STPB-FIT9201/2-G | 3/4" | 1 #10 (G) | GROUND JUNCTION BOX | STPB-PBOX-RIO2A | |
| STPB-FIT9201-I | 3/4" | 1 #16 2-CONDUCTOR TWISTED PAIR SHIELDED CABLE (I) | STPB-FIT-9201 | STPB-PBOX-RIO2A | |
| STPB-FIT9201-PC | 3/4" | 2 #10 (P) 2 #14 (C) 1 #10 (G) | STPB-FIT-9201 | STPB-PBOX-RIO2A | |
| STPB-FIT9202-I | 3/4" | 1 #16 2-CONDUCTOR TWISTED PAIR SHIELDED CABLE (I) | STPB-FIT-9202 | STPB-PBOX-RIO2A | |
| STPB-FIT9202-PC | 3/4" | 2 #10 (P) 2 #14 (C) 1 #10 (G) | STPB-FIT-9202 | STPB-PBOX-RIO2A | |
| STPB-FIT9302-G | 3/4" | 1 #10 (G) | GROUND JUNCTION BOX | STPB-PBOX-RIO2A | |
| STPB-FIT9302-I | 3/4" | 1 #16 2-CONDUCTOR TWISTED PAIR SHIELDED CABLE (I) | STPB-FIT-9302 | STPB-PBOX-RIO2A | |

PUMP BUILDING

| CONDUIT TAG | TRADE SIZE | CABLE/WIRE DESCRIPTION | FROM | TO | ADDITIONAL REQUIREMENTS |
|-------------------|------------|---|-----------------|-----------------|-------------------------|
| STPB-FIT9302-PC | 3/4" | 2 #10 (P) 2 #14 (C) 1 #10 (G) | STPB-FIT-9302 | STPB-PBOX-RIO2A | |
| STPB-M1-P | 3/4" | 3 #10 (P) 1 #10 (G) | STPB-PDP-001 | MONORAIL HOIST | |
| STPB-PBRIO2A-C1 | 2-1/2" | 54 #14 (C) 20 #14 (SP) 5 #10 (G) | STPB-PBOX-RIO2A | RIO2A | |
| STPB-PBRIO2A-C2 | 2-1/2" | 54 #14 (C) 20 #14 (SP) 5 #10 (G) | STPB-PBOX-RIO2A | RIO2A | |
| STPB-PBRIO2A-C3 | 1-1/4" | 6 #10 (P) 6 #14 (C) 5 #10 (G) | STPB-PBOX-RIO2A | RIO2A | |
| STPB-PBRIO2A-C4 | 1-1/4" | 10 #14 (C) 8 #14 (SP) 4 #10 (G) | STPB-PBOX-RIO2A | RIO2A | |
| STPB-PBRIO2A-COM1 | 3/4" | 2 COPPER ETHERNET CABLE (COM) | STPB-PBOX-RIO2A | RIO2A | |
| STPB-PBRIO2A-COM2 | 2" | 6 TYPE I FIBER OPTIC CABLE(S) - 36 FIBER (COM) | STPB-PBOX-RIO2A | RIO2A | |
| STPB-PBRIO2A-I1 | 3/4" | 2 #16 2-CONDUCTOR TWISTED PAIR SHIELDED CABLE (I) | STPB-PBOX-RIO2A | RIO2A | |
| STPB-PBRIO2A-I2 | 3/4" | 2 #16 2-CONDUCTOR TWISTED PAIR SHIELDED CABLE (I) | STPB-PBOX-RIO2A | RIO2A | |
| STPB-PBRIO2A-I3 | 1-1/4" | 4 #16 2-CONDUCTOR TWISTED PAIR SHIELDED CABLE (I) | STPB-PBOX-RIO2A | RIO2A | |
| STPB-PCU1-P | 3/4" | 3 #10 (P) 1 #10 (G) | STPB-PDP-001 | STPB-PCU-1 | |
| STPB-PDP1-F | 3" | 3 500 kCMIL (P) 1 #2 (G) | STPB-ATS-001 | STPB-PDP-001 | |
| STPB-PMUSGT1-C1 | 3/4" | 6 #10 (I) 1 #10 (G) | MCC-SGT1 | STPB-CP-PMUSGT1 | |
| STPB-PMUSGT1-C2 | 3/4" | 2 #10 (P) 1 #10 (G) | MCC-SGT1 | STPB-CP-PMUSGT1 | |
| STPB-PMUSGT1-C3 | 3/4" | 1 VENDOR CABLE (C) | MCC-SGT1 | STPB-CP-PMUSGT1 | |
| STPB-PMUSGT1-C4 | 3/4" | 3 #10 (I) 1 #6 (G) | MCC-SGT1 | STPB-CP-PMUSGT1 | |
| STPB-PMUSGT2-C1 | 3/4" | 6 #10 (I) 1 #10 (G) | MCC-SGT2 | STPB-CP-PMUSGT2 | |
| STPB-PMUSGT2-C2 | 3/4" | 2 #10 (P) 1 #10 (G) | MCC-SGT2 | STPB-CP-PMUSGT2 | |
| STPB-PMUSGT2-C3 | 3/4" | 1 VENDOR CABLE (C) | MCC-SGT2 | STPB-CP-PMUSGT2 | |

| PUMP BUILDING | | | | | |
|-----------------|------------|--|----------------|-----------------|-------------------------|
| CONDUIT TAG | TRADE SIZE | CABLE/WIRE DESCRIPTION | FROM | TO | ADDITIONAL REQUIREMENTS |
| STPB-PMUSGT2-C4 | 3/4" | 3 #10 (I) 1 #6 (G) | MCC-SGT2 | STPB-CP-PMUSGT2 | |
| STPB-PSLTSLP1-C | 3/4" | 2 #14 (C) 1 #10 (G) | STPB-PSL-TSLP1 | STPB-PB-TSLP1 | |
| STPB-PSLTSLP2-C | 3/4" | 2 #14 (C) 1 #10 (G) | STPB-PSL-TSLP2 | STPB-PB-TSLP2 | |
| STPB-PSLTSLP3-C | 3/4" | 2 #14 (C) 1 #10 (G) | STPB-PSL-TSLP3 | STPB-PB-TSLP3 | |
| STPB-PSLTSLP4-C | 3/4" | 2 #14 (C) 1 #10 (G) | STPB-PSL-TSLP4 | STPB-PB-TSLP4 | |
| STPB-PSLTSLP5-C | 3/4" | 2 #14 (C) 1 #10 (G) | STPB-PSL-TSLP5 | STPB-PB-TSLP5 | |
| STPB-PSLTSLP6-C | 3/4" | 2 #14 (C) 1 #10 (G) | STPB-PSL-TSLP6 | STPB-PB-TSLP6 | |
| STPB-RIO2A-C1 | 1-1/4" | 24 #14 (C) 6 #14 (SP) 1 #10 (G) | PB01-CCP-01 | RIO2A | |
| STPB-RIO2A-C2 | 2" | 36 #14 (C) 10 #14 (SP) 1 #10 (G) | PB01-CCP-01 | RIO2A | |
| STPB-RIO2A-C3 | 1" | 12 #14 (C) 4 #14 (SP) 1 #10 (G) | PB01-CCP-03 | RIO2A | |
| STPB-RIO2A-COMA | 2" | 3 TYPE I FIBER OPTIC CABLE(S) - 36 FIBER (COM) | STPB-CP-001 | STPB-PBOX-RIO2A | |
| STPB-RIO2A-COMB | 2" | 3 TYPE I FIBER OPTIC CABLE(S) - 36 FIBER (COM) | STPB-CP-001 | STPB-PBOX-RIO2A | |
| STPB-SGT1-C1 | 2" | 36 #14 (C) 12 #14 (SP) 1 #10 (G) | MCC-SGT1 | PB01-CCP-01 | |
| STPB-SGT1-C2 | 3/4" | 2 #14 (C) 2 #14 (SP) 1 #10 (G) | MCC-SGT1 | STPB-PBOX-RIO2A | |
| STPB-SGT1-COM | 3/4" | 1 COPPER ETHERNET CABLE (COM) | MCC-SGT1 | STPB-PBOX-RIO2A | |
| STPB-SGT2-C1 | 1-1/4" | 16 #14 (C) 8 #14 (SP) 1 #10 (G) | MCC-SGT2 | PB01-CCP-01 | |
| STPB-SGT2-C2 | 3/4" | 2 #14 (C) 2 #14 (SP) 1 #10 (G) | MCC-SGT2 | STPB-PBOX-RIO2A | |

PUMP BUILDING

| CONDUIT TAG | TRADE SIZE | CABLE/WIRE DESCRIPTION | FROM | TO | ADDITIONAL REQUIREMENTS |
|----------------|------------|---|----------------|-----------------|-------------------------|
| STPB-SGT2-C3 | 3/4" | 4 #14 (C) 4 #14 (SP) 1 #10 (G) | MCC-SGT2 | PB01-CCP-03 | |
| STPB-SGT2-COM | 3/4" | 1 COPPER ETHERNET CABLE (COM) | MCC-SGT2 | STPB-PBOX-RIO2A | |
| STPB-SGTL-F | 2-1/2" | 4 250 kCMIL (P) 1 #4 (G) | STPB-XFMR-SGTL | SGTL | |
| STPB-SPD1-C | 3/4" | 2 #14 (C) 2 #14 (SP) 1 #10 (G) | STPB-SPD-PDP1 | STPB-PBOX-RIO2A | |
| STPB-SPD1-P | 1" | 3 #6 (P) 1 #6 (G) | STPB-PDP-001 | STPB-SPD-PDP1 | |
| STPB-SVTSLP2-C | 3/4" | 2 #14 (C) 1 #10 (G) | STPB-SV-TSLP2 | STPB-PB-TSLP2 | |
| STPB-SVTSLP4-C | 3/4" | 2 #14 (C) 1 #10 (G) | STPB-SV-TSLP4 | STPB-PB-TSLP4 | |
| STPB-SVTSLP5-C | 3/4" | 2 #14 (C) 1 #10 (G) | STPB-SV-TSLP5 | STPB-PB-TSLP5 | |
| STPB-SVTSLP6-C | 3/4" | 2 #14 (C) 1 #10 (G) | STPB-SV-TSLP6 | STPB-PB-TSLP6 | |
| STPB-TIT9001-I | 3/4" | 1 #16 2-CONDUCTOR TWISTED PAIR SHIELDED CABLE (I) | STPB-TIT-9001 | STPB-PBOX-RIO2A | |
| STPB-TSLP1-C | 3/4" | 6 #14 (C) 4 #14 (SP) 1 #10 (G) | STPB-PB-TSLP1 | PB01-CCP-03 | |
| STPB-TSLP2-C | 1" | 14 #14 (C) 4 #14 (SP) 1 #10 (G) | STPB-PB-TSLP2 | PB01-CCP-01 | |
| STPB-TSLP2-PSH | 3/4" | 3 #10 (P) 2 #10 (SH) 1 #10 (G) | MCC-SGT2 | STPB-TSLP-2 | |
| STPB-TSLP3-C | 3/4" | 6 #14 (C) 4 #14 (SP) 1 #10 (G) | STPB-PB-TSLP3 | PB01-CCP-01 | |
| STPB-TSLP4-C | 1" | 14 #14 (C) 4 #14 (SP) 1 #10 (G) | STPB-PB-TSLP4 | PB01-CCP-01 | |
| STPB-TSLP5-C | 1" | 14 #14 (C) 4 #14 (SP) 1 #10 (G) | STPB-PB-TSLP5 | PB01-CCP-01 | |
| STPB-TSLP5-PSH | 3/4" | 3 #10 (P) 2 #10 (SH) 1 #10 (G) | MCC-SGT1 | STPB-TSLP-5 | |

PUMP BUILDING

| CONDUIT TAG | TRADE SIZE | CABLE/WIRE DESCRIPTION | FROM | TO | ADDITIONAL REQUIREMENTS |
|------------------|------------|---------------------------------------|----------------|------------------|-------------------------|
| STPB-TSLP6-C | 1" | 14 #14 (C) 4 #14 (SP) 1 #10 (G) | STPB-PB-TSLP6 | PB01-CCP-01 | |
| STPB-TSLP6-PSH | 3/4" | 3 #10 (P) 2 #10 (SH) 1 #10 (G) | MCC-SGT1 | STPB-TSLP-6 | |
| STPB-XFMRCPP1-F | 3/4" | 3 #8 (P) 1 #10 (G) | STPB-PDP-001 | STPB-XFMR-CPP1 | |
| STPB-XFMRCPP1-IG | 1" | 1 #2 (IG) | STPB-XFMR-CPP1 | GROUNDING SYSTEM | |
| STPB-XFMRSGL-F | 1-1/2" | 3 #1/0 (P) 1 #4 (G) | STPB-PDP-001 | STPB-XFMR-SGTL | |
| STPB-ZSTSLP1-C | 3/4" | 4 #14 (C) 2 #14 (SP) 1 #10 (G) | STPB-ZS-TSLP1 | STPB-PB-TSLP1 | |
| STPB-ZSTSLP2-C | 3/4" | 4 #14 (C) 2 #14 (SP) 1 #10 (G) | STPB-ZS-TSLP2 | STPB-PB-TSLP2 | |
| STPB-ZSTSLP3-C | 3/4" | 4 #14 (C) 2 #14 (SP) 1 #10 (G) | STPB-ZS-TSLP3 | STPB-PB-TSLP3 | |
| STPB-ZSTSLP4-C | 3/4" | 4 #14 (C) 2 #14 (SP) 1 #10 (G) | STPB-ZS-TSLP4 | STPB-PB-TSLP4 | |
| STPB-ZSTSLP5-C | 3/4" | 4 #14 (C) 2 #14 (SP) 1 #10 (G) | STPB-ZS-TSLP5 | STPB-PB-TSLP5 | |
| STPB-ZSTSLP6-C | 3/4" | 4 #14 (C) 2 #14 (SP) 1 #10 (G) | STPB-ZS-TSLP6 | STPB-PB-TSLP6 | |

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| CONDUIT TAG | TRADE SIZE | CABLE/WIRE DESCRIPTION | FROM | TO | ADDITIONAL REQUIREMENTS |
| EBB/STPB-FO-COMA | 2" | 1 TYPE I FIBER OPTIC CABLE(S) - 36 FIBER (COM) | EBB1-DCP-01 | PB01-CCP-01 | |
| EBB/STPB-FO-COMAB | 2" | 2 TYPE I FIBER OPTIC CABLE(S) - 36 FIBER (COM) | EBB1-DCP-01 | PB01-CCP-01 | |
| EBB/STPB-FO-COMB | 2" | 1 TYPE I FIBER OPTIC CABLE(S) - 36 FIBER (COM) | EBB1-DCP-01 | PB01-CCP-01 | |
| GT-CPDMC1-C | 1" | 8 #14 (C) 4 #14 (SP) 1 #10 (G) | GT-CP-DMC1 | STPB-PBOX-RIO2A | |
| GT-CPDMC1-P | 1" | 3 #10 (P) 1 #10 (G) | STPB-PDP-001 | GT-CP-DMC1 | |
| GT-CPDMC2-C | 1" | 8 #14 (C) 4 #14 (SP) 1 #10 (G) | GT-CP-DMC2 | STPB-PBOX-RIO2A | |
| GT-CPDMC2-P | 1" | 3 #10 (P) 1 #10 (G) | STPB-PDP-001 | GT-CP-DMC2 | |
| GT-CPDMC3-C | 1" | 8 #14 (C) 4 #14 (SP) 1 #10 (G) | GT-CP-DMC3 | STPB-PBOX-RIO2A | |
| GT-CPDMC3-P | 1" | 3 #10 (P) 1 #10 (G) | STPB-PDP-001 | GT-CP-DMC3 | |
| GT-CPDMC4-C | 1" | 8 #14 (C) 4 #14 (SP) 1 #10 (G) | GT-CP-DMC4 | STPB-PBOX-RIO2A | |
| GT-CPDMC4-P | 1" | 3 #10 (P) 1 #10 (G) | STPB-PDP-001 | GT-CP-DMC4 | |
| GT-CPOCP1A-C | 1" | 6 #14 (C) 4 #14 (SP) 1 #10 (G) | GT-CP-OCP1A | STPB-PBOX-RIO2A | |
| GT-CPOCP1A-COMA | 2" | 1 TYPE I FIBER OPTIC CABLE(S) - 36 FIBER (COM) | GT-CP-OCP1A | STPB-CP-001 | |
| GT-CPOCP1A-COMB | 2" | EMPTY | GT-CP-OCP1A | STPB-CP-001 | |
| GT-CPOCP1AFAN-P | 1" | 3 #8 (P) 1 #10 (G) | GT-CP-OCP1A | GT-OCFAN-01 | |
| GT-CPOCP1AHT-P | 1" | 2 #10 (P) 1 #10 (G) | GT-CP-OCP1A | HEAT TRACE | |
| GT-CPOCP1A-P | 1-1/2" | 3 #1 (P) 1 #8 (G) | MCC-SGT1 | GT-CP-OCP1A | |
| GT-CPOCP1ARP-P | 3/4" | 3 #10 (P) 1 #10 (G) | GT-CP-OCP1A | GT-SRP-01 | |
| GT-CPOCP2A-C | 1" | 6 #14 (C) 4 #14 (SP) 1 #10 (G) | GT-CP-OCP2A | STPB-PBOX-RIO2A | |

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| CONDUIT TAG | TRADE SIZE | CABLE/WIRE DESCRIPTION | FROM | TO | ADDITIONAL REQUIREMENTS |
| GT-CPOCP2A-COMA | 2" | 1 TYPE I FIBER OPTIC CABLE(S) - 36 FIBER (COM) | GT-CP-OCP2A | STPB-CP-001 | |
| GT-CPOCP2A-COMB | 2" | EMPTY | GT-CP-OCP2A | STPB-CP-001 | |
| GT-CPOCP2AFAN-P | 1" | 3 #8 (P) 1 #10 (G) | GT-CP-OCP2A | GT-OCFAN-01 | |
| GT-CPOCP2AHT-P | 1" | 2 #10 (P) 1 #10 (G) | GT-CP-OCP2A | HEAT TRACE | |
| GT-CPOCP2A-P | 1-1/2" | 3 #1 (P) 1 #8 (G) | MCC-SGT2 | GT-CP-OCP2A | |
| GT-CPOCP2ARP-P | 3/4" | 3 #10 (P) 1 #10 (G) | GT-CP-OCP2A | GT-SRP-02 | |
| GT-CPTSCP1-C | 1-1/4" | 16 #14 (C) 4 #14 (SP) 1 #10 (G) | GT-CP-TSCP1 | STPB-PBOX-RIO2A | |
| GT-CPTSCP1-I | 1" | 1 #16 2-CONDUCTOR TWISTED PAIR SHIELDED CABLE (I) | GT-CP-TSCP1 | STPB-PBOX-RIO2A | |
| GT-CPTSCP1-P | 1" | 3 #8 (P) 1 #10 (G) | STPB-PDP-001 | GT-CP-TSCP1 | |
| GT-CPTSCP2-C | 1-1/4" | 16 #14 (C) 4 #14 (SP) 1 #10 (G) | GT-CP-TSCP2 | STPB-PBOX-RIO2A | |
| GT-CPTSCP2-I | 1" | 1 #16 2-CONDUCTOR TWISTED PAIR SHIELDED CABLE (I) | GT-CP-TSCP2 | STPB-PBOX-RIO2A | |
| GT-CPTSCP2-P | 1" | 3 #8 (P) 1 #10 (G) | STPB-PDP-001 | GT-CP-TSCP2 | |
| GT-CPTSCP3-C | 1-1/4" | 16 #14 (C) 4 #14 (SP) 1 #10 (G) | GT-CP-TSCP3 | STPB-PBOX-RIO2A | |
| GT-CPTSCP3-I | 1" | 1 #16 2-CONDUCTOR TWISTED PAIR SHIELDED CABLE (I) | GT-CP-TSCP3 | STPB-PBOX-RIO2A | |
| GT-CPTSCP3-P | 1" | 3 #8 (P) 1 #10 (G) | STPB-PDP-001 | GT-CP-TSCP3 | |
| GT-CPTSCP4-C | 1-1/4" | 16 #14 (C) 4 #14 (SP) 1 #10 (G) | GT-CP-TSCP4 | STPB-PBOX-RIO2A | |
| GT-CPTSCP4-I | 1" | 1 #16 2-CONDUCTOR TWISTED PAIR SHIELDED CABLE (I) | GT-CP-TSCP4 | STPB-PBOX-RIO2A | |
| GT-CPTSCP4-P | 1" | 3 #8 (P) 1 #10 (G) | STPB-PDP-001 | GT-CP-TSCP4 | |
| GT-FCSTSCP1-C | 1" | 8 #14 (C) 4 #14 (SP) 1 #12 (G) | GT-FCS-TSCP1 | GT-CP-TSCP1 | |

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| CONDUIT TAG | TRADE SIZE | CABLE/WIRE DESCRIPTION | FROM | TO | ADDITIONAL REQUIREMENTS |
| GT-FCSTSCP2-C | 1" | 8 #14 (C) 4 #14 (SP) 1 #12 (G) | GT-FCS-TSCP2 | GT-CP-TSCP2 | |
| GT-FCSTSCP3-C | 1" | 8 #14 (C) 4 #14 (SP) 1 #12 (G) | GT-FCS-TSCP3 | GT-CP-TSCP3 | |
| GT-FCSTSCP4-C | 1" | 8 #12 (C) 4 #12 (SP) 1 #12 (G) | GT-FCS-TSCP4 | GT-CP-TSCP4 | |
| GT-LETSCP1-I | 3/4" | 1 VENDOR CABLE (I) | GT-LE-TSCP1 | GT-CP-TSCP1 | |
| GT-LETSCP2-I | 3/4" | 1 VENDOR CABLE (I) | GT-LE-TSCP2 | GT-CP-TSCP2 | |
| GT-LETSCP3-I | 3/4" | 1 VENDOR CABLE (I) | GT-LE-TSCP3 | GT-CP-TSCP3 | |
| GT-LETSCP4-I | 3/4" | 1 VENDOR CABLE (I) | GT-LE-TSCP4 | GT-CP-TSCP4 | |
| GT-MPC-001-1,3 | 1" | 2 #10 (P) 1 #10 (G) | GT-MPC-001 | GT SITE LTG | |
| GT-MPC-001-10 | 1" | 2 #8 (P) 1 #10 (G) | GT-MPC-001 | OC 1 REC | |
| GT-MPC-001-11 | 1" | 2 #10 (P) 1 #10 (G) | GT-MPC-001 | GT-1B,2B INT LTG | |
| GT-MPC-001-12 | 1" | 2 #8 (P) 1 #10 (G) | GT-MPC-001 | OC 2 REC | |
| GT-MPC-001-13 | 3/4" | 2 #10 (P) 1 #10 (G) | GT-MPC-001 | GT-LC-001 | |
| GT-MPC-001-14,16 | 1" | 2 #4 (P) 1 #8 (G) | GT-MPC-001 | GT SITE WELD REC | |
| GT-MPC-001-15,17,19 | 3/4" | 3 #10 (P) 1 #10 (G) | GT-MPC-001 | GT-SPD-MPC1 | |
| GT-MPC-001-2 | 1" | 2 #8 (P) 1 #10 (G) | GT-MPC-001 | GT-1A REC | |
| GT-MPC-001-4 | 1" | 2 #8 (P) 1 #10 (G) | GT-MPC-001 | GT-2A REC | |
| GT-MPC-001-5 | 1" | 2 #8 (P) 1 #10 (G) | GT-MPC-001 | WEST OC & BT TASK LTG | |
| GT-MPC-001-6 | 1" | 2 #8 (P) 1 #10 (G) | GT-MPC-001 | GT-1B REC | |
| GT-MPC-001-7 | 1" | 2 #8 (P) 1 #10 (G) | GT-MPC-001 | EAST OC & BT TASK LTG | |

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| CONDUIT TAG | TRADE SIZE | CABLE/WIRE DESCRIPTION | FROM | TO | ADDITIONAL REQUIREMENTS |
| GT-MPC-001-8 | 1" | 2 #8 (P) 1 #10 (G) | GT-MPC-001 | GT-2B REC | |
| GT-MPC-001-9 | 1" | 2 #10 (P) 1 #10 (G) | GT-MPC-001 | GT-1A,2A INT LTG | |
| GT-MPC1-F | 1-1/4" | 3 #2 (P) 1 #8 (G) | STPB-PDP-001 | GT-MPC-001 | |
| GT-RD1-PSH | 3/4" | 3 #10 (P) 2 #10 (SH) 1 #10 (G) | GT-CP-DMC1 | GT-RD-001 | |
| GT-RD2-PSH | 3/4" | 3 #10 (P) 2 #10 (SH) 1 #10 (G) | GT-CP-DMC2 | GT-RD-002 | |
| GT-RD3-PSH | 3/4" | 3 #10 (P) 2 #10 (SH) 1 #10 (G) | GT-CP-DMC3 | GT-RD-003 | |
| GT-RD4-PSH | 3/4" | 3 #10 (P) 2 #10 (SH) 1 #10 (G) | GT-CP-DMC4 | GT-RD-004 | |
| GT-RVTSCP1-PC | 1" | 7 #14 (C) 4 #14 (SP) 1 #10 (G) | GT-CP-TSCP1 | GT-RV-TSCP1 | |
| GT-RVTSCP2-PC | 1" | 7 #14 (C) 4 #14 (SP) 1 #10 (G) | GT-CP-TSCP2 | GT-RV-TSCP2 | |
| GT-RVTSCP3-PC | 1" | 7 #14 (C) 4 #14 (SP) 1 #10 (G) | GT-CP-TSCP3 | GT-RV-TSCP3 | |
| GT-RVTSCP4-PC | 1" | 7 #14 (C) 4 #14 (SP) 1 #10 (G) | GT-CP-TSCP4 | GT-RV-TSCP4 | |
| GT-TS1-C | 1" | 4 #14 (C) 4 #14 (SP) 2 #10 (G) 2 #10 (SH) | GT-TS-001 | GT-CP-DMC1 | |
| GT-TS2-C | 1" | 4 #14 (C) 4 #14 (SP) 2 #10 (G) 2 #10 (SH) | GT-TS-002 | GT-CP-DMC2 | |
| GT-TS3-C | 1" | 4 #14 (C) 4 #14 (SP) 2 #10 (G) 2 #10 (SH) | GT-TS-003 | GT-CP-DMC3 | |

| SITE | | | | | |
|-------------|------------|--|-------------|-------------|-------------------------|
| CONDUIT TAG | TRADE SIZE | CABLE/WIRE DESCRIPTION | FROM | TO | ADDITIONAL REQUIREMENTS |
| GT-TS4-C | 1" | 4 #14 (C) 4 #14 (SP) 2 #10 (G) 2 #10 (SH) | GT-TS-004 | GT-CP-DMC4 | |
| GT-TSCP1-P | 3/4" | 1 VENDOR CABLE (P) 1 #10 (G) | GT-CP-TSCP1 | GT-TSCP-001 | |
| GT-TSCP2-P | 3/4" | 1 VENDOR CABLE (P) 1 #10 (G) | GT-CP-TSCP2 | GT-TSCP-002 | |
| GT-TSCP3-P | 3/4" | 1 VENDOR CABLE (P) 1 #10 (G) | GT-CP-TSCP3 | GT-TSCP-003 | |
| GT-TSCP4-P | 3/4" | 1 VENDOR CABLE (P) 1 #10 (G) | GT-CP-TSCP4 | GT-TSCP-004 | |
| SGTL-15 | 3/4" | 2 #10 (P) 1 #10 (G) | SGTL | RIO2A | |
| SGTL-27 | 3/4" | 2 #10 (P) 1 #10 (G) | SGTL | STPB-CP-001 | |

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SECTION 16200
WIRING (600 VOLTS AND BELOW)

PART 1 GENERAL

1.01 SUMMARY

- A. Furnish and install the field wiring as specified herein and as shown on the PLANS.
- B. Furnish and install all wiring required to make the electrical system completely and satisfactorily operable. Comply with the National Electrical Code and all applicable federal, state, and local codes, regulations and ordinances.
- C. The requirements of this section also applies in whole to the installation of the fiber-optic cables and Ethernet copper cables. Fiber optic cables and are specified in Section 17600 "Distributed Control System" of the Specifications.

1.02 RELATED REQUIREMENTS

- A. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
- B. It is the CONTRACTOR's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR's Work.
- C. The PLANS designate the type, number, and size of field wiring.
- D. Related work as called for on the PLANS, as specified herein or in other Sections of the Specifications.

1.03 SUBMITTALS

- A. Submit shop drawings in accordance with Section 01300 of the Contract Specifications.
- B. Submit Operations and Maintenance Manuals (O&M) in accordance with Section 01730 of the Contract Specifications. O&M Manuals shall include copies of the approved shop drawings, factory and on-site/field test data.

PART 2 PRODUCTS

2.01 GENERAL REQUIREMENTS

- A. All wire and cable on this project shall be new, unused, in good condition and shall be delivered in standard coils, packages or reels. Submit wire samples when requested by the OWNER. Final acceptance of wire shall be made by the OWNER or its representative.

2.02 SINGLE CONDUCTOR - GENERAL ELECTRICAL POWER SYSTEM AND AUXILIARY ELECTRICAL SYSTEM WIRING

A. All wire shall be 98% conductivity copper, stranded, single conductor Type XHHW-2. This wire shall have moisture resistant insulation and clean stripping characteristics. Wire shall be marked at minimum distance of every ten feet (10') with the size, type and voltage of the wires as well as the manufacturer's name and measurement markers. All neutral and ground wires shall be insulated and identified and marked.

B. The pigmentation of the wire insulation shall conform to the color table listed below:

| Phase | 277/480 Volts | 120/208 Volts AC | 24 Volts DC |
|------------------------|---------------|------------------|-------------|
| ΦA | Brown | Red | ----- |
| ΦB | Yellow | Black | ----- |
| ΦC | Purple | Blue | ----- |
| Neutral | Gray | White | Brown |
| Ground | Green | Green | Green |
| Motor Space Heater (H) | ----- | Black | ----- |
| DC (+) | ----- | ----- | Blue |

C. Any interlock wiring installed in one device with power from another device shall be properly marked.

D. The minimum wire size shall be No.10 for all wiring unless shown otherwise on the PLANS.

E. Departures from the sizes shown shall be made only in those cases in which the National Electric Code requires the use of larger conductors.

F. General Electrical Power System and Auxiliary Electrical System Wiring shall be as manufactured by General Cable Company, The Okonite Company, or approved equal.

2.03 SIGNAL AND COMMUNICATION WIRING

A. 4-20 Milliamp Signal wiring:

1. Number of Pairs: One
2. Wire Size: #16 AWG
3. Type of Conductors: Stranded copper conductors, twisted
4. Individual Conductor Insulation: PVC
5. Individual Conductor Insulation Color: Positive (+) is Black, Negative (-) is White.
6. Drain Wire: Tinned copper
7. Overall Shield: Aluminum-mylar shield.

8. Overall Jacket: PVC
9. Overall Jacket Color: Black.
10. Manufacturer: Samuel Moore and Company, Dekoron Division, Cat. No. 1852 or approved equal.

B. Multi-Conductor RTD Temperature Signal Wiring:

1. Number of Triads: One
2. Wire Size: #16 AWG
3. Type of Conductors: Stranded copper conductors, twisted
4. Individual Conductor Insulation: PVC
5. Individual Conductor Insulation Color: Positive (+) is Black, Negative (-) is White, Sense (S) is Red.
6. Drain Wire: Tinned copper
7. Overall Shield: Aluminum-mylar shield.
8. Overall Jacket: PVC
9. Overall Jacket Color: Black.
10. Manufacturer: Samuel Moore and Company, Dekoron Division, Cat. No. 1862 or approved equal.

C. Ethernet Data Communication Wiring:

1. Number of Pairs: Four
2. Wire Size: #23 AWG
3. Type of Conductors: solid copper conductors, twisted
4. Individual Conductor Insulation: 300 volt polyolefin
5. Individual Conductor Insulation Color: White/Blue Stripe, Blue, White/Orange Stripe, Orange, White/Green Stripe, Green, White/Brown Stripe, Brown
6. Drain Wire: No. 24 AWG Tinned copper
7. Overall Shield: Aluminum-mylar shield.
8. Overall Jacket: PVC, include ripcord
9. Overall Jacket Color: Blue.

10. Maximum Attenuation at 100 MHz: 18.9 dB per 100 meters of cable length
11. Maximum Attenuation at 250 MHz: 31.2 dB per 100 meters of cable length
12. Manufacturer: Belden, Catalog No. 7851A, or approved equal. .
13. Agency Compliance: ANSI/TIA/EIA-568 B.2-1 Category 6

D. Fiber Optic

1. Refer to Section 17600 Distributed Control System.

2.04 SINGLE CONDUCTOR CONTROL WIRING

- A. Single conductor control wiring shall be 98% conductivity copper, stranded, single conductor Type XHHN-2. This wire shall have moisture resistant insulation and clean stripping characteristics. Wire shall be marked at minimum distance of every ten feet (10') with the size, type and voltage of the wires as well as the manufacturer's name and measurement markers.
- B. Conductors shall have a minimum size of #14 AWG, unless shown otherwise on the PLANS. The color of the wire shall be RED.
- C. Single Conductor Control Wiring shall be as manufactured by General Cable Company, The Okonite Company, or approved equal.

2.05 WIRE TAGGING

A. Wire Tags:

1. Rating: Flame-Retardant,
2. Style: Heavy-Duty Industrial Grade
3. Type: Heat Shrinkable type.
4. Character Height: 1/8 inch.
5. Maximum Length: 2 inches.
6. Text Type: Typed with indelible marking process. Handwritten shall not be accepted.
7. Color: All wire tags shall be White with the following exception:
 - a. Exception: Use Yellow for instrumentation/control circuits as described in Section 17200.
8. Manufacturer: "Raychem type Heavy-Duty Industrial Grade ShrinkMark Heat-Shrinkable Marking Sleeves", or approved equal. Utilize "Raychem" Portable-Marking-System" complete with wire tag cartridges, or approved equal.

2.06 MISCELLANEOUS

- A. Wire Pulling Lubricant: Ideal #77 or approved equal

- B. Vertical cable supports (in conduit): O.Z. Gedney Type “S”, or approved equal.
- C. Multi-Cable Connector Blocks:
 - 1. Use only for power wiring termination for motors rated 600V and below
 - 2. 600V rated
 - 3. Insulated with UV rated chemical resistant plastisol compound that will not support combustion
 - 4. Suitable for use with fine stranded extra-flexible wiring
 - 5. Suitable for use with aluminum and copper conductors
 - 6. U. L. 486A Listed
 - 7. Pre-filled with an oxide inhibitor.
 - 8. Manufacturer: “Polaris Connectors” Series Polaris Grey, or approved equal.
- D. Corrosion Resistant and Moisture Repelling Electrical Coating/Spray:
 - 1. Color: Clear. Coordinate spray color with the Owner. Furnish and install the color requested by the Owner at No Additional Cost to the Owner.
 - 2. Type: Corrosion resistant and moisture repellent fast drying spray coating sealant
 - 3. Manufacturer: “3M” 1601 Clear-Color Fast Drying Sealer and Insulator, or approved equal.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Before wire is pulled into any conduit, thoroughly swab the conduit to remove all foreign material and to permit the wire to be pulled into a clean, dry conduit. Use wire pulling lubricant in pulling any wire. Pull all conductors into their respective conduits by hand except where written permission of the OWNER is secured to the contrary.
- B. Furnish and install the previously specified vertical cable supports in conduit were required by the NEC.
- C. No wire splices shall be accepted except as permitted below:
 - 1. **SPLICING OF 208/120 VOLT LIGHTING AND RECEPTACLE CIRCUITING:**
 - a. General: Perform all splicing in splice/junction boxes dedicated for this purpose.
 - b. For splices where wiring is:
 - 1) #10 AWG and smaller: Utilize 600 volts WeatherProof Wire-Nut Wire Connectors. The WeatherProof Wire-Nut Wire Connectors shall be twist-on type and shall be pre-filled (factory- filled) with Silicone-Based Sealant for maximum

- protection against Moisture and Corrosion. The WeatherProof Wire-Nut Wire Connectors shall be as manufactured by IDEAL Model 61, 62, or 63 WeatherProof Wire-Nut Wire Connectors, or approved equal.
- 2) All other sizes: Use the Multi-Cable Connector Blocks as Specified in 2.07.C, this Section of the Specifications.
- D. For wiring termination to motors rated 600 volt and below, use the Multi-Cable Connector Blocks as Specified in 2.07.C, this Section of the Specifications.
- E. All wiring connections must be insulated with 600 volt insulation system
- F. Tagging:
1. Tag all power, Instrumentation and Controls, Fiber Optic Cables, and all other types of auxiliary electrical wiring and cables at both ends with the specified heat shrinkable tags and heat shrink tags.
 2. Tag per Subsection 3.03 of this Section of the Specifications and per the OWNER's cable and wire tagging standards.
 3. Tag each wire in a Multi-Conductor cable in addition to the overall cable itself.
 4. Group wiring routed in pullboxes that are routed in common conduits and tag each wiring group inside each pullbox with nameplates as follows:
 - a. Type: 3-ply, 1/8" thick, rigid thermoset phenolic resin laminated cellulose paper base engraving stock per ASTM D-709, Type I. Nameplates shall be ASTM Grade ES-1, ES-2, or ES-3 as applicable for the face and lettering colors specified hereinafter. Flexible or acrylic tags will be not be accepted.
 - b. Color: White-Black-White.
 - c. Lettering: 1/4 inch height, minimum, engraved through the face layer to the melamine middle layer.
 - d. Accessories: Provide holes for mechanical fastening.
 5. Secure each phenolic tag (where required) with a minimum of two nylon cable ties, one at each end of the tag.
- G. Ground shielded instrument cables at one point only, i.e.; at the final destination in the associated instrument and control cabinets.
- H. Terminate stranded wiring by use of lugs, clamps or pressure type terminals.
- I. After all wiring connections have been made, the Contractor shall apply the Corrosion Resistant and Moisture Repelling Electrical Coating/Spray to all wiring connections. Coordinate application with the Owner. The extent of spray application is further clarified as follows:
1. Spray shall be applied for all terminations of the following types of connections at a minimum:
 - a. termination points, terminals, terminal blocks, ground bar, neutral bar/bus,
 - b. lugs of circuit breakers, buses, doors, etc.
 - c. exposed/stripped ends of each conductor, etc.

- d. bolt-on connections, split-bolt connections, ring lugs, etc.
 - e. submersible roadway connectors, compression connectors, connector blocks, etc.
 - f. all other connection types not listed above
2. Spray shall be applied for all terminations at the following types of equipment at a minimum:
- a. Local and main control panels, field instruments, junction boxes, field control stations, control relays, signal isolators, selector switches, pushbuttons, etc.,
 - b. Panelboards, transformers, motor control centers, manual motor starters, contactors, light switches, light fixtures, etc.
 - c. Motor termination enclosures, valve actuators, cathodic protection system, package control panels of process equipment, etc.
 - d. Security system devices, cameras, roadway gate operators, etc.
 - e. Convenience receptacles, scada receptacles, etc.
 - f. All other types of equipment not listed above.

3.02 TESTS

- A. Perform all tests as outlined in Section 16800 and all other tests which are necessary to determine that the electrical wiring system is in satisfactory operating condition. Wiring shall be tested end-to-end after it is pulled in the conduit system.

3.03 WIRE TAGGING METHODOLOGY

- A. Single Conductor Wire Tagging Scheme:

- 1. All single conductor control and power wiring shall be tagged utilizing the source and destination method. In general, as minimum each tag shall be comprised of various fields which are:
 - a. Device Identifiers,
 - b. Terminal Numbers and,
 - c. Equipment Identification name
- 2. The following is the format that shall be used for each control power single conductor wire tag:

| | | | | | | | |
|-------------------|---|-----------------|-------------------------------|---|-------------------|---|-----------------|
| XXXX | - | XX | (XXXX-XXXX-XXXX | / | XXXX | - | XX) |
| Device Identifier | | Terminal Number | Equipment Identification Name | | Device Identifier | | Terminal Number |

- a. The tag information to the left refers to the point of termination. Tag information in parenthesis refers to the point of origination. Note: For wiring within the boundaries of a piece of equipment, The Equipment identification name shall not be required, only the Device Identifier and the Terminal Number from the point of origination. Examples to this exception would be, wiring from one terminal strip to another within the same control panel, etc.

3. The following provides a brief description to each of the fields required within a single wire tag:

| FIELD | DESCRIPTION |
|--------------------------------|--|
| Device Identifier: | A four (4) alphanumeric character field that shall uniquely identify a device within a piece of equipment. Examples are: TB1, for Terminal Block Number 1, and CR02 for Control Relay #02, etc. |
| Terminal Number: | A two (2) alphanumeric character field that shall identify which specific point on the Device the wire must be terminated to. Refer to manufacturer's labeling or record drawings for Device Terminal Numbers. |
| Equipment Identification Name: | A twelve (12) alphanumeric character field that shall be the same as the physical Equipment Identification Nameplate attached to the equipment. |

B. Single Conductor Wire Tagging Scheme in a Multiconductor Cable:

1. All single conductor control and instrument wiring (in Multiconductor Instrument or Control Cables) shall be tagged utilizing the source and destination method. In general, each tag shall be comprised of various fields which are 1) Device Identifiers, 2) Terminal Numbers, and 3) Equipment Identification Name, as minimum.
2. The following is the format that shall be used for each single conductor wire tag in a multiconductor cable (Instrumentation or Control wiring Cables):

| | | | | | |
|-------------------|---|-----------------|----------|---|------------------|
| XXXX | - | XX | (XXXX | / | XX) |
| Device Identifier | | Terminal Number | Cable ID | | Conductor Number |

- a. The tag information to the left refers to the point of termination. Tag information in parenthesis refers to the point of origination.

3. The following provides a brief description to each of the fields required within a single tag (in a Multiconductor Cable):

| FIELD | DESCRIPTION |
|----------------------------------|---|
| Device Identifier: | A four (4) alphanumeric character field that shall uniquely identify a device within a piece of equipment. Examples are: TB1, for Terminal Block Number 1, and CR02 for Control Relay #02, etc. |
| Terminal Number: | A two (2) alphanumeric character field that shall identify which specific point on the Device the wire must be terminated to. Refer to manufacturer's labeling or record drawings for Device Terminal Numbers. |
| Cable Identification (Cable ID): | A five (5) alphanumeric character field that shall uniquely identify a cable within the facility. The first character shall identify the cable type as follows: C - for Control Cables I - for Instrumentation Cables P - for Power Cables The remaining four (4) alphanumeric characters shall make-up a unique number for a given cable type within the facility. |

C. Overall Cable Tag of a Multiconductor Cable:

1. In addition to tagging each single conductor in a multiconductor cable (as described in 3.03 B, above), the overall jacket of each multiconductor cable shall also be tagged to uniquely identify each cable within the facility. In general, each cable tag shall be comprised of various fields which are 1) Cable Identification (Cable ID), and 2) Equipment Identification Name, as minimum.
2. The following is the format that shall be used for overall cable tag of each multiconductor cable:

| | | | |
|----------|---------------------------------------|---|---|
| XXXX | (XXXX-XXXX-XXXX | / | XXXX-XXXX-XXXX) |
| Cable ID | Source Equipment Identification Name. | | Destination Equipment Identification Name |

- a. The tag information to the left refers to the actual cable Identification (name). Tag information in parenthesis refers to the Identification Name of the Equipment at point of origination (source), followed by the Identification Name of the Equipment at the point of termination (Destination Point).

3. The following provides a brief description to each of the fields required within a cable tag:

| FIELD | DESCRIPTION |
|--|--|
| - Cable Identification (Cable ID): | A five (5) alphanumeric character field that shall uniquely identify a cable within the facility. The first character shall identify the cable type as follows: C -for Control Cables I - for Instrumentation Cables P - for Power Cables The remaining four (4) alphanumeric characters shall make-up a unique number for a given cable type within the facility. |
| - Source Equipment Identification Name: | A twelve (12) alphanumeric character field that shall be the same as the physical Equipment Identification Nameplate attached to the source (origination) equipment. |
| - Destination Equipment Identification Name: | A twelve (12) alphanumeric character field that shall be the same as the physical Equipment Identification Nameplate attached to the destination equipment (equipment at point of termination). |

4. All cable tags (except in Manholes, handholes, above ground cable closets, and in cable tray system), shall be of 3-ply engraved plastic (phenolic) with background color, letter sizes, etc. as follows:

| Cable Type | Tag Color | Color of Lettering | Letter Height |
|------------------------|-----------|--------------------|---------------|
| 600 volt Power Cable | Orange | White | 3/16" (min.) |
| 600 volt Control Cable | Orange | White | 3/16" (min.) |
| Instrumentation Cable | Black | White | 3/16" (min.) |

3.04 MEASUREMENT AND PAYMENT

A. No separate measurement or payment for work performed under this Section. Include cost of same in Contract price bid for work of which this is a component part.

END OF SECTION

SECTION 16250
BOXES AND CABINETS

PART 1 GENERAL

1.01 SUMMARY

- A. Furnish and install all cabinets, junction boxes, pull boxes and outlet boxes as shown on the PLANS, required by the Specifications or N.E.C., or as otherwise necessary for a satisfactory operating system.

1.02 RELATED REQUIREMENTS

- A. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
- B. It is the CONTRACTOR's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR's Work.
- C. Related work as called for on the PLANS, as specified herein or in other Sections of the Specifications.

1.03 SUBMITTALS

- A. Submit shop drawings in accordance with the Section 01300 of the Specifications.
- B. Submit Operations and Maintenance Manuals (O&M) in accordance with Section 01730 of the Specifications. O&M Manuals shall include copies of the approved shop drawings, factory and on-site/field test data.

PART 2 PRODUCTS

2.01 JUNCTION AND PULL BOXES

- A. Lighting and power, signal, telephone, voice communication, instrumentation and controls, and any other junction and pull boxes hereinafter specified or shown on the PLANS shall be as provided as follows:
 - 1. Outdoor boxes shall be NEMA-4X Type 316-Stainless Steel Boxes. Boxes shall be equipped with hinged doors complete with 1/4 (quarter) turn door latches.
 - 2. Indoor boxes in non-environmentally controlled rooms shall be as follows:
 - a. All areas:
 - 1) Smaller than or equal to 12" wide x 12" high: 99.0% copper-free rigid Aluminum NEMA-4X corrosion resistant and water tight boxes.
 - 2) Larger than 12" side x 12" high: NEMA-4X Type 316-stainless steel Boxes.
 - b. Boxes shall be equipped with hinged doors complete with 1/4 (quarter) turn door latches.

3. Indoor boxes in environmentally controlled rooms shall be as follows:
 - a. NEMA 12 with ANSI No. 61 Gray finish
 - b. Boxes shall be equipped with hinged doors complete with 1/4 (quarter) turn door latches.
- B. Additional requirements for terminal junction box installed over existing recessed panelboard enclosure where specifically shown on the PLANS as "GT-JBOX-LP1A":
 1. Junction box shall be a field modified standard product of the junction box manufacturer. An opening shall be field cut in the rear of the junction box, with the cut edges deburred and ground smooth. Refer to the details shown on the PLANS. Furnish and install extruded U-channel rubber grommets around the entire perimeter cut edge of the rear box opening and coordinate grommet size with enclosure metal thickness. Grommets shall be model EX-150 as manufactured by Western Rubber and Supply, or approved equal.
 2. Furnished and installed a full size back panel for mounting power distribution blocks inside of the existing panelboard enclosure as shown on the PLANS. Back panel shall be painted white and be the standard product of the junction box manufacturer.
 3. Furnish and install power distribution blocks as specified hereinafter for terminating the field interconnect wiring. Furnish and install all mounting hardware and make all final connections. All hardware shall be Type 316 stainless steel. Label all terminal blocks (phases A, B, and C) with a nameplate as specified in subsection 2.03, this Section of the Specifications.
 4. Power Distribution Blocks:
 - a. Rating: 600 volts A.C., with 115 ampere continuous ampere at minimum.
 - b. Number of Poles: As required.
 - c. Type: Single Layer, mounted on insulated base.
 - d. Temperature Rating: 75 degrees C.
 - e. Material: Tin-plated aluminum alloy, suitable for use with copper conductors.
 - f. Wire Range: As required to terminate the field wiring shown on the PLANS.
 - g. UL approved.
 - h. Accessories:
 - 1) Clear protective plexiglass slotted cover for each block
 - 2) Marking surface.
 - i. Manufacturer: Allen-Bradley Bulletin 1492-50X with 1492-PBC1 cover, or approved equal.
 5. Plastic wireway and wireway covers shall be per Section 17200.
- C. Boxes or cabinets shall be not less than 6-inches deep and their size determined by the requirements of , and in compliance with the National Electrical Code (NEC).
- D. Each type of boxes and cabinet on the project shall be manufactured by a single manufacturer.
- E. Manufacturer:
 1. Hoffman Concept Series, Rittal, Millbank, or approved equal.

2.02 DEVICE BOXES FOR CONVENIENCE/SPECIAL PURPOSE RECEPTACLES AND LIGHT SWITCHES

- A. Boxes for convenience/special-purpose receptacles shall be as specified in Section 16300 “Wiring Devices”.
- B. Boxes for Light Switches shall be as specified in Section 16300 “Wiring Devices”.

2.03 NAMEPLATES

- A. General:
 - 1. Type: 3-ply, 1/8” thick, rigid thermoset phenolic resin laminated cellulose paper base engraving stock per ASTM D-709, Type I. Nameplates shall be ASTM Grade ES-1, ES-2, or ES-3 as applicable for the face and lettering colors specified hereinafter. Flexible or acrylic tags will be not be accepted
 - 2. Color: White-Black-White
 - 3. Lettering: 1/4 inch height, minimum, engraved through the face layer to the melamine middle layer
 - 4. Accessories: Provide holes for mechanical fastening. Provide adhesive backplane where required in Part 3, Execution.

PART 3 EXECUTION

3.01 APPLICATION

- A. General:
 - 1. Pullboxes shall be used only to reduce the number of bends for conduit, supports, taps, troughs and similar applications. No splicing shall be performed in pullboxes.
 - 2. Junction boxes shall only be used where shown on the PLANS. Any other use of junction boxes other than for receptacle and lighting circuit wiring, is not permitted.
 - 3. Outlet boxes shall be used for ceiling or wall mounting of light fixtures, receptacles, open type manual motor starters, and where required by the PLANS and Specifications to facilitate proper connection to equipment.

3.02 INSTALLATION

- A. Set box square and true with building surfaces. Secure boxes firmly to support channels. Coordinate final location of boxes with other trades to avoid any conflicts.
- B. Utilize specified support channels, then secure/mount boxes and cabinets to the support channels. All mounting hardware shall be Type 316-stainless steel. Equipment support channels shall be per the requirements of Section 16150 “Raceways, Fittings, and Supports”. Additionally, refer to details shown on the PLANS.

C. Tagging:

1. Tag each box with the name as it appears on the PLANS using the specified nameplates. Exception: Use nameplates specified in Section 16300 "Wiring Devices" for manual motor starters located in environmentally controlled rooms, light switches, and outlet boxes.
2. Attach identification nameplates with two stainless steel screws.

D. Cap all outlets not used under this Contract with blank outlet covers.

E. Furnish and install labels as required by the NEC.

3.03 MEASUREMENT AND PAYMENT

- A. No separate measurement or payment for work performed under this Section. Include cost of same in Contract price bid for work of which this is a component part.

END OF SECTION

SECTION 16300
WIRING DEVICES

PART 1 GENERAL

1.01 SUMMARY

- A. Furnish and install all necessary wiring devices at the locations indicated on the PLANS and as specified herein.

1.02 RELATED REQUIREMENTS

- A. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
- B. It is the CONTRACTOR's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR's Work.
- C. Related work as called for on the PLANS, as specified herein or in other Sections of the Specifications.

1.03 SUBMITTALS

- A. Submit shop drawings in accordance with Section 01300 of the Contract Specifications. Include manufacturer's catalog data/notification certifying Aluminum Device Boxes, as specified hereinafter, to be 99.0% copper-free.
- B. Submit Operations and Maintenance Manuals (O&M) in accordance with Section 01730 of the Contract Specifications. O&M Manuals shall include copies of the approved shop drawings, factory and on-site/field test data.

PART 2 PRODUCTS

2.01 LIGHT SWITCHES

- A. General: Shall be provided complete with light switch, box, and coverplate with the following features.
- B. Light switch:
 - 1. Specification grade, 20 amp, 120/277 volts
 - 2. Provide the number of poles as required by the PLANS.
 - 3. Provide maintained action type operation, unless momentary action is specifically required by the PLANS.
 - 4. Ivory color switch handle operator.
 - 5. Manufacturer: Pass and Seymour No. PS20AC, or approved equal.

2.02 120 VOLTS AC, COVENIENCE RECEPTACLES

- A. General: Shall be provided complete with receptacle, box, and coverplate with the following features:
- B. Receptacle
 - 1. Specification grade
 - 2. Duplex, 3-wire, polarized grounding type, rated 20 amp, 125 volt, 60 Hertz
 - 3. Ivory color
 - 4. Manufacturer: Hubbell No. HBL5362I, Bryant, Pass and Seymour, or approved equal.
- C. Ground Fault Interrupter Receptacle:
 - 1. Provide where G.F.I receptacles are indicated on the PLANS
 - 2. Specification grade, weather-resistant type,
 - 3. Duplex, 3-wire, polarized grounding type, rated 20 amp, 125 volt, 60 Hertz..
 - 4. Red indicator light
 - 5. Test and Reset pushbutton
 - 6. Ivory color.
 - 7. Manufacturer: Pass & Seymour Cat. No. 2095TRWR, or approved equal.
- D. Box: Provide as hereinafter specified.

2.03 DEVICE ENCLOSURES

- A. General: Furnish and install the type of device enclosure complete with coverplate and necessary adapters as specified herein, fully coordinated with the operating environment and mounting configuration.
- B. Die Cast Aluminum, 99.0% copper-free, one piece construction, suitable for surface mounting
- C. Single and Multi-Gang Weatherproof Outlet boxes, as required.
- D. 3/4-inch threaded hubs, minimum box depth shall be 2-5/8". Use 2-3/4" depth when "gang" arrangements of outlets are used.
- E. Manufacturer: Crouse-Hinds Series FS or FD, Appleton, or approved equal.

F. Coverplate:

1. Receptacles: Die Cast Aluminum 99.0% copper-free, complete with rubber gasket, as manufactured by Crouse-Hinds WLRS (single cover) and WLRD (duplex cover), or approved equal.
2. Switches: Die Cast Aluminum, 99.0% copper-free, gasketed coverplate with external operating handle for on-off operation (with hole for lock), as manufactured by Crouse-Hinds or approved equal.
3. Raintight while-in-use type hinged coverplate: Suitable suitable for installation outdoors in a wet location. Provide gasket, adapter, and mounting hardware to mount cover to device enclosure. Cover material shall be extra deep clear thermoplastic. Provide as manufactured by Leviton "Raintight While In Use Covers" Model 5977-DCL or approved equal.

2.04 WELDING RECEPTACLE

- A. General: Shall be provided complete with receptacle, box, and coverplate with the following features:
1. 50 amperes, 250 Volt, 2 pole, 3 wire grounding, straight blade (NEMA 6-50R configuration) receptacles
 2. Manufacturer: Hubbell, Cat. No. HBL9367, with Hubbell HBL9420 coverplate, or approved equal.

2.05 OUTLET BOXES FOR PENDANT MOUNTED LIGHT FIXTURES

- A. General: Furnish and install the type of outlet box complete with coverplate and necessary adapters as specified herein, fully coordinated with the operating environment and mounting configuration.
- B. Die Cast Aluminum, 99.0% copper-free, one piece construction, with mounting tabs/lugs, suitable for surface mounting
- C. Suitable to support pendant mounted fixtures weighing up to 125 pounds.
- D. Four threaded holes for cover attachment at minimum
- E. 3/4-inch threaded hubs, minimum box depth shall be 3-1/8".
- F. Manufacturer: Crouse-Hinds Series GRFX, Appleton, or approved equal.
- G. Swivel Coverplate: Ball type, 11 degree swing, Die Cast Aluminum 99.0% copper-free, complete with rubber gasket, as manufactured by Crouse-Hinds Series ARB662, or approved equal.

2.06 DUPLEX SCADA RECEPTACLES

- A. General: Shall be provided complete with receptacle, box, and coverplate with the following features:
1. Faceplates shall be available with multiple module spaces for both vertical and horizontal applications. Each faceplate shall accept individual modules for both copper and fiber optic applications. Faceplates shall be flush mounted with a clean look and be available with labels. Faceplate color shall be white. For each faceplate, furnish and install a minimum of two (2) MINI-COM TX6A 10GIG UTP Jack Modules as manufactured by Panduit. Data outlet faceplate shall be manufactured by Panduit with Four Module Space, model CFPL4 with white color. The top two spaces shall be occupied by the specified mini com devices, the bottom two spaces shall be covered with mini com blanks for future use. Furnish and install data label with plastic cover as manufactured by Panduit. Provide label and clear plastic cover as manufactured by Panduit for all mini com module spaces, even the unused, blank spaces. Label each non-blank mini com device data outlet on each face plate with indelible, permanent printing system with black color imprinted ¼" high capital lettering attached to faceplate and covered by plastic clear cover, as manufactured by Panduit. Submit proposed data labeling for review and approval by OWNER and ENGINEER prior to commencing data labeling. Clearly distinguish SCADA data outlets from other data outlets using color coded mini com data outlet color and faceplate icon color. Coordinate with OWNER for color preference of the data outlets and icons.
- B. Box: Provide as hereinafter specified. Exception: The coverplate required by subsection 2.03, this Section of the Specifications, is not required for these receptacles.

2.07 MISCELLANEOUS

- A. All mounting hardware shall be Type 316-stainless steel.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Mounting: Device enclosures shall be surface mounted on conduit support channels per Section 16150 and as shown on the PLANS.
- B. Mounting heights shall be as follows unless otherwise noted on the PLANS:
1. Light switches: 48 inches above finished floor to center of switch
 2. Receptacles: 36 inches above finished floor to center of receptacle.
- C. Tagging:
1. Tag all receptacles and switches
 2. Tagging format: "ckt. LPY-XX" where Y represents the panel number (i.e. for "LP-01", Y is 1) and XX represents the circuit number. Add voltage if other than 120V.

3. Tag type:
 - a. Type: 3-ply, 1/8" thick, rigid thermoset phenolic resin laminated cellulose paper base engraving stock per ASTM D-709, Type I. Nameplates shall be ASTM Grade ES-1, ES-2, or ES-3 as applicable for the face and lettering colors specified hereinafter. Flexible or acrylic tags will be not be accepted.
 - b. Color: White-Black-White.
 - c. Lettering: Engraved through the face layer to the melamine middle layer.
 - d. Accessories: adhesive backplane.
 - D. Provide 6-inches offset for receptacles or other wiring devices mounted on opposite sides of a wall.
 - E. Do not use switch boxes as junction boxes for switch and receptacle.
 - F. Set box square and true with building surfaces.
 - G. Maintain symmetry of all devices as closely as possible within the Architectural Section contained. For example, center a light fixture over a doorway, or a receptacle in a section of wall, if shown in that approximate position.
 - H. Verify location of receptacles and switches in finished rooms. In centering devices and locating device boxes, allow for overhead pipes, and mechanical equipment; etc., and correct any inaccuracy from failure to do so without extra expense to the OWNER.
 - I. Cap all device boxes not used under this Contract with blank outlet covers.
- 3.02 MEASUREMENT AND PAYMENT
- A. No separate measurement or payment for work performed under this Section. Include cost of same in Contract price bid for work of which this is a component part.

END OF SECTION

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SECTION 16350
LIGHTING

PART 1 GENERAL

1.01 SUMMARY

- A. Furnish and install lighting fixtures, outdoor lighting photocells, and electrical lighting contactors as specified herein and as indicated on the PLANS.

1.02 RELATED REQUIREMENTS

- A. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
- B. It is the CONTRACTOR's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR's Work.
- C. The PLANS designate the number of lighting fixtures and other requirements for the proposed equipment specified under this Section.
- D. Related work as called for on the PLANS, as specified herein or in other Sections of the Specifications.

1.03 SUBMITTALS

- A. Submit shop drawings in accordance with Section 01300 of the Contract Specifications. Submit a lighting fixture brochure for each fixture indicating catalog number, pertinent physical characteristics, and complete photometric data.
- B. Submit Operations and Maintenance Manuals (O&M) in accordance with Section 01730 of the Contract Specifications. O&M Manuals shall include copies of the approved shop drawings, factory and on-site/field test data.

1.04 SPARE PARTS

- A. Provide quantities of spare parts as follows:
 - 1. Spare HID Lamps: 100 percent spare HID lamps for each lamp size and voltage specified
 - 2. Spare LED lamp modules: Five percent spare LED lamp modules for each fixture type specified, with minimum of 3 lamp modules of each type.
 - 3. Spare Drivers: Five percent spare drivers for each fixture type specified, with minimum of 6 drivers of each type.
 - 4. Spare Ballasts: Five percent spare ballasts for each fixture type specified, with minimum of 6 drivers of each type.
 - 5. Photocells: Provide 3 spare photocells of each type specified.

PART 2 PRODUCTS

2.01 GENERAL

A. General:

1. Furnish and install fixtures in accordance with the requirements of this specification and the requirements of the PLANS. Fixtures shall bear the U.L. label and such labels shall apply to entire fixture as installed.
2. Deliver lamps to job site in original cartons. Lamps shall be as manufactured by General Electric, Sylvania, or approved equal.

2.02 LIGHT FIXTURES

- #### A. General: Multiple types of light fixtures are required for this project and as described hereinafter. Refer to the PLANS for application of the specific light fixture types.

2.03 ACCESSORIES

- #### A. Deliver all fixtures complete with suspension chains, accessories, canopies, hickey, casings, sockets, holders, reflectors, ballast, diffusers, frames, recessing boxes, etc.

2.04 PROTECTION

- #### A. Protect all fixtures, lenses and louvers from damage. Leave protective coverings on lenses and louvers until fixtures are installed. Replace all damaged lenses and louvers immediately prior to final inspection at no cost to the OWNER.

2.05 SUBSTITUTIONS

- #### A. Comply with requirements of the Contract Specifications.

2.06 PHOTOCELL FOR OUTDOOR AND PERIMETER LIGHTING CONTROL

A. General:

1. Type: 180 degree Swivel type
2. Conduit Size: 1/2" NPT nipple
3. Enclosure: Metallic gray polycarbonate enclosure (lexan)
4. Timer: Internal two (2) minutes built-in delay to prevent false switching
5. Contacts: Rated for 15 ampere at 208/120 volts A.C. Coordinate voltage required with the requirements of the PLANS.
6. Accessories:
 - a. Field adjustable Light level selector for "on/off" adjustment
 - b. NEMA-4X stainless steel gasketed outlet box coverplate complete with 1/2" threaded opening for Photocell mounting.

7. Manufacturer: TORK catalog No. 2002 (208 volts A.C. units) and TORK catalog No. 2001 (120 volts A.C. units), or approved equal.

2.07 LIGHTING CONTACTOR

- A. Furnish and install totally enclosed Lighting Contactors and associated controls, as specified hereinafter and as shown on the PLANS.
- B. General:
 1. Number of Poles and Configuration: Four (4) pole single throw
 2. Contactor Type: Electrically held
 3. Contacts Configuration: Normally Open (N.O.) contacts.
 4. Minimum continuous current rating of the contacts: 60 amperes at 208 volts AC, unless otherwise shown to be greater on the PLANS.
 5. Contact Application: Suitable to drive Ballast Tungsten and Inductive Loads
 6. Certifications: U.L. listed
 7. Symmetrical Short Circuit Rating: Minimum of 10,000 ampere at 208 volts A.C. unless shown to be greater on the PLANS.
 8. Control Coil Voltage: 120 volts A.C..
 9. All control wiring and control wiring labeling shall be per specification 16200.
 10. Accessories:
 - a. Two wire control relay per manufacturer's standard product to facilitate the control logic as shown on the PLANS.
 - b. Vibration isolators
 - c. Hand-Off-Auto selector switch. Selector switch shall be 30-millimeter, rated NEMA-4X corrosion resistant oil-tight industrial grade with minimum contact rating of 10-amperes at 120 volts AC. Miniature size selector switches will not be accepted. Mount to face of contactor enclosure and wire as shown on the PLANS.
- C. Enclosure: NEMA-4X Type 316 Stainless Steel gasketed cabinet enclosure.
- D. Manufacturer: "General Electric Company "G.E." Series CR360L with specified accessories, or approved equal.

PART 3 EXECUTION

3.01 INSTALLATION AND TESTING

- A. Maintain perfect horizontal and vertical alignment of fixtures throughout.
- B. Do not locate circuiting splices or taps within an arm, stem or chain.

- C. Replace any damaged fixture or lens at no cost to the OWNER.
- D. Support all pendant fixtures with swivel type hangers.
- E. Install recessed luminaries to permit removal from below, to gain access to outlet or prewired fixture box.
- F. Locate fixtures where shown on the PLANS and coordinate fixture location such to avoid interference with piping, fans, ducts, and other obstructions. Obtain approval of any location differing from the location shown on the PLANS.
- G. Furnish and install outlet box as specified in Section 16300 "Wiring Devices" for photocell mounting. Orient and make wiring connections to photocell per photocell manufacturer's recommendations.

3.02 MEASUREMENT AND PAYMENT

- A. No separate measurement or payment for work performed under this Section. Include cost of same in Contract price bid for work of which this is a component part.

END OF SECTION

SECTION 16450
600 VOLTS AND BELOW DRY TYPE TRANSFORMERS

PART 1 GENERAL

1.01 SUMMARY

- A. Furnish and install dry type transformers as specified herein and as shown on the PLANS.

1.02 RELATED REQUIREMENTS

- A. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
- B. It is the CONTRACTOR's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR's Work.
- C. The PLANS designate the number, size and rating of transformers required.
- D. Related work as called for on the PLANS, as specified herein or in other Sections of the Specifications.

1.03 SUBMITTALS

- A. Submit shop drawings in accordance with Section 01300 of the Specifications. For each individual Transformer include:
 - 1. Dimensioned/scaled plan view and elevation,
 - 2. Ratings, product data sheets, including weight and nameplate data
 - 3. Wiring connection diagram
- B. Submit Operations and Maintenance Manuals (O&M) in accordance with Section 01730 of the Specifications. O&M Manuals shall include copies of the approved shop drawings, factory and on-site/field test data.

1.04 DELIVERY, STORAGE AND HANDLING

- A. Deliver, receive, unload and handle equipment by suitable methods. Inspect for damage before accepting shipment. Wrap in protective plastic wrapping and store in humidity controlled environment. Use heat lamps as necessary to prevent condensation.

1.05 ACCEPTABLE MANUFACTURER

- A. General Use (Power & Lighting) Dry-Type Ventilated Isolation Transformers shall be Watchdog Premium Quality units manufactured by Sorgel (Square D) class 7430, or approved equal

- B. Ultra-Isolator, Highly Shielded and Noise and Transient Voltage Suppressing Transformers IN ALL AREAS: shall be as manufactured by "Eaton" Power-Suppress T7 Series 30 Ultra-Isolation Transformers with "K" Factor 13 Rating (with electrostatic shielding) and all other specified accessories, or approved equal.

PART 2 PRODUCT

2.01 GENERAL AND BASIC REQUIREMENTS FOR ALL 600 VOLT AND BELOW DRY TYPE TRANSFORMERS

A. Type:

- 1. Manufacturer's premium quality dry type transformers.
- 2. Primary and secondary voltage ratings, and, KVA ratings to be as shown on the PLANS.
- 3. All windings shall be copper.
- 4. Transformers shall be of ventilated type.

B. Core and coils:

- 1. Continuous wound core impregnated with non-hygroscopic, thermosetting varnish.
- 2. Core to be of high grade, non-aging silicon steel with high magnetic permeability.
- 3. Core and coil bolted to base of enclosure but isolated from it by rubber vibration absorbing mounts.

C. Additional Requirements:

- 1. Furnish with four (4) 2-1/2 percent full capacity primary taps, two (2) above and two (2) below rated primary voltage.
- 2. Core is to be visibly grounded to enclosure by means of a flexible grounding conductor sized per NEMA, IEEE and ANSI standards.
- 3. All transformers shall be U.L. listed and certified and carry the U.L. label.
- 4. Sound levels: Guaranteed not to exceed the following:

| <u>Transformer KVA Range</u> | <u>Sound Level</u> |
|------------------------------|--------------------|
| 15 to 50KVA | 45dB |
| 51 to 150KVA | 50dB |
| 151 to 300KVA | 55dB |

2.02 GENERAL USE (POWER & LIGHTING) VENTILATED DRY TYPE ISOLATION TRANSFORMERS

A. General:

1. Transformers shall be suitable for indoor installation. Comply with all requirements/specifications outlined in subsection 2.01, above (Basic and General Requirements for All 600 volt and Below Dry Type Transformers).
2. Transformers shall meet NEMA TP-1 efficiency requirements.

B. Temperature Rise and Insulation System:

1. Temperature Rise: 80 degrees Celsius above a 40 degree Celsius. ambient
2. All insulating materials shall be in accordance with NEMA ST20 standards for a 220 degree Celsius. U.L. component recognized insulation system.

C. Enclosure: Heavy gauge sheet steel with ventilation openings designed in accordance with U.L., NEMA and the N.E.C. Phosphatized, primed and finished with ANSI#61 gray baked enamel. Provide surface/wall mounting brackets where surface/wall mounting is shown on the PLANS.

2.03 CONTROL AND INSTRUMENT POWER ULTRA-ISOLATOR, HIGHLY SHIELDED AND NOISE SUPPRESSION TRANSFORMERS

A. General:

1. Transformers shall be of the dry type suitable for indoor installation. Comply with all specifications requirements outlined in subsection 2.01, above (Basic and General Requirements for All Dry Type Transformers) in addition to the requirement specified in this subsection 2.02. Note: Requirements hereinafter specified take precedence over the requirements outlined in subsection 2.01 above

B. Ratings:

1. Input Voltage Range: Plus or minus 10 percent of nominal.
2. Isolation: All winding are to be electrically isolated from each other
3. Temperature Rise and Insulation System:
 - a. Temperature Rise: 115 degrees Celsius above a 40 degree Celsius. ambient.
 - b. All insulating materials shall be in accordance with NEMA ST20 standards for a 200 degree Celsius. U.L. component recognized insulation system.
4. Load Regulation: 3.5 percent or less from no load to full load at unity power factor.
5. Frequency Range: 57 Hz to 63 Hz.
6. Overload Capacity: 500 percent for one cycle with no adverse effects

7. Harmonic Distortion: 1 percent added to the output waveform, at maximum
 8. Efficiency: 95 percent at all load levels, at minimum.
 9. Maximum Audible Noise: Less than 50 dBA measured at a distance of 3-feet.
 10. Common-Mode Noise Attenuation: 120 dB minimum
 11. Shielding: 100 percent electrostatic shield wound between the primary and secondary windings. Shield must be connected to a terminal inside the transformer enclosure.
 12. "K" Factor Rating: 13, U. L. Listed.
- C. Enclosure: Heavy gauge sheet steel with ventilation openings designed in accordance with U.L., NEMA and the N.E.C. Phosphatized, primed and finished with gray baked enamel.

2.04 NAMEPLATES

- A. General:
1. Type: 3-ply, 1/8" thick, rigid thermoset phenolic resin laminated cellulose paper base engraving stock per ASTM D-709, Type I. Nameplates shall be ASTM Grade ES-1, ES-2, or ES-3 as applicable for the face and lettering colors specified hereinafter. Flexible or acrylic tags will be not be accepted
 2. Color: White-Black-White
 3. Lettering: 3/8 inch height, minimum, engraved through the face layer to the melamine middle layer.
 4. Accessories: Provide holes for mechanical fastening.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install at the locations shown on the PLANS in accordance with manufacturer's recommendations. Furnish and install equipment pads as shown on the PLANS for floor mounted transformers and surface/wall mounted brackets for surface/wall mounted transformers as required.
- B. Make grounding connections as required by the N.E.C. and as shown on the PLANS.

C. Tagging:

1. Tag each transformer with the name as it appears on the PLANS using the specified nameplates attached with stainless steel screws. Include the following additional information: name of the load served by the transformer, primary voltage rating, secondary voltage ratings, KVA rating, phase, wire, primary and secondary winding configuration, and transformer type.

3.02 TESTS AND INSPECTIONS

- A. All test results (including factory test) shall be certified.

3.03 MEASUREMENT AND PAYMENT

- A. No separate measurement or payment for work performed under this Section. Include cost of same in Contract price bid for work of which this is a component part.

END OF SECTION

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SECTION 16500
PANELBOARDS

PART 1 GENERAL

1.01 SUMMARY

- A. Furnish and install panelboards and surge protective devices where indicated on the PLANS and as specified herein.
- B. The subsequent document entitled "Appendix A – Panelboard Schedule" is hereto made part of this section and includes a listing of certain proposed panelboards and other requirements. This schedule in "Appendix A" is not inclusive of all equipment required by this Contract. Refer to Part 2 of this section for additional requirements in addition to those listed in "Appendix A". Conduit size as shown in Appendix A may increase for conduit systems routed underground/underslab/etc., in a duct bank system. Refer to the PLANS and other Sections of the Specifications for additional information.

1.02 RELATED REQUIREMENTS

- A. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
- B. It is the CONTRACTOR's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR's Work
- C. The PLANS designate the type, size, ratings, and other requirements of the equipment specified in this Section.
- D. Related work as called for on the PLANS, as specified herein or in other Sections of the Specifications.

1.03 SUBMITTALS

- A. Submit Shop Drawings in accordance with Section 01300 of the Specifications. Include panelboard dimensions, ratings, branch circuit breaker schedules and main circuit breakers size. Submit protective device coordination curves and current limiting circuit breaker/fuse peak current let through curves, and transformer impedance, where applicable.
- B. Submit Operations and Maintenance Manuals (O&M) in accordance with Section 01730 of the Specifications. O&M Manuals shall include copies of the approved shop drawings, and on-site/field test data.

1.04 QUALITY ASSURANCE

- A. Panelboards to be U.L. labeled "U.L. 67", "U.L. 508" and meeting Fed. Spec. WP-115, Type 1, Class 1, latest revisions. Breakers to meet Fed. Spec. WC-375, latest revision.

1.05 DELIVERY, STORAGE AND HANDLING

- A. Deliver, receive, unload and handle equipment by suitable methods. Store in humidity controlled environment in original packaging, or, in protective plastic wrapping.
- B. Additional project job site storage requirements: Upon delivery to the project site and prior to final installation, protect and store in accordance with the following:
 - 1. Environmentally protected and stored in climate controlled (temperature, humidity, and non-corrosive class) environment at the job site. Size, furnish and install temporary gaseous air scrubbers, air conditioners, and additional environmental control equipment complete with branch circuiting conduit/wire as required to maintain in a controlled environment at the following conditions:
 - a. Ambient Dry Bulb Temperature:
 - 1) Minimum: 68 degrees Fahrenheit.
 - 2) Maximum: 85 degrees Fahrenheit.
 - b. Ambient Relative Humidity: Maximum: 50%.
 - c. Ambient Corrosion Level: International Society of Automation Class: G1
 - 2. Every effort shall be made to provide all necessary electrical power connections ready for immediate connection to equipment upon arrival of equipment on jobsite.
 - 3. Upon arrival of equipment onto job site, a maximum of ten (10) minutes shall be allowed for equipment to be left without to allow proper transition of power of equipment, especially any 120 VAC powered equipment, to ensure all air conditioning, heating, and gaseous air scrubbing equipment are fully operational with a maximum of a 10 minute down time during this transition of power.
 - 4. Furnish and install replacement air scrubber media, air filters, etc., as required for proper operation of the environmental control equipment.

1.06 ACCEPTABLE MANUFACTURERS

- A. All Panelboards on the project shall be manufactured by a single Panelboard manufacturer.
- B. 480 volts A.C., 3-phase, 3-wire Power Distribution Class Panelboards with main bus current rating of 300 ampere or greater, where indicated on the PLANS:
 - 1. Square D Company Series I-LINE with specified accessories. Approved equal Panelboards manufactured by Cutler-Hammer or General Electric are acceptable as equals.
 - 2. These panelboards will be known as Type I panelboards hereinafter
- C. 480 volts A.C., 3-phase, 3-wire Panelboards with main bus current rating lower than 300 ampere, where indicated on the PLANS:
 - 1. Square D Company Series "NF" with specified accessories. Approved equal Panelboards manufactured by Cutler-Hammer or General Electric are acceptable as equals.
 - 2. These panelboards will be known as Type II panelboards hereinafter

- D. 208/120 volts A.C., 3-phase, 4-wire Panelboards - Cutler-Hammer Corporation Type POW-R-Line 3a with specified accessories. Approved equal Panelboards manufactured by Square-D Company or General Electric are acceptable as equals.

PART 2 PRODUCTS

2.01 GENERAL

A. Bussing Requirements

1. Main Bus
 - a. All buses shall be tin-plated copper, distributed phase sequence type, and shall extend the full length of the panelboard.
 - b. Refer to the PLANS for bus ratings. Ratings to be established by heat rise tests with maximum hot spot temperature on any connector or bus bar not to exceed 50 degrees Celsius rise above an ambient of 40 degrees Celsius.
 - c. Circuit numbering to be such that odd numbered circuits are on the left and even numbered on the right facing the front of the panel.
2. Ground Bus
 - a. Each panelboard shall have a tin plated copper ground bus for connecting equipment grounds. Ground bus shall not be connected to the neutral bus.
3. Isolated Ground Bus:
 - a. In addition to the equipment ground bar, where called for per subsection 3.02, this Section of the Specifications, furnish a second tin-plated isolated ground bar in panelboard which shall be electrically isolated from the panelboard cabinet/enclosure by 600 volt isolators. Isolated ground bar shall have the same current rating as the phase-bussing (bus rating) of the panelboard.

B. Circuit Breakers

1. General:
 - a. Circuit breakers to be single pole, two pole or three pole as shown on the PLANS.
 - b. All breakers to be quick-make, quick-break thermal magnetic molded case bolt-on type, with inverse time thermal trip and instantaneous time magnetic trip. Multi-pole breakers to be common trip with a single trip handle. Provide overload tripping elements in each pole. A tripped condition to be indicated by the breaker assuming a neutral position between "ON" and "OFF".
 - c. Circuit breakers to be equipped with individually insulated, braced and protected connectors. Affix large, permanent, individual circuit numbers to each breaker in a uniform position.
 - d. Circuit breakers for lighting circuit protection are not to be larger than 20 amperes.
 - e. Key interlocks shall be provided for circuit breakers where shown on the PLANS.
 - f. Padlock attachments shall be provided for circuit breakers where shown on the PLANS.
 - g. Provide lugs as required to facilitate the field wiring termination shown on the PLANS.

2. Circuit breaker interrupting ratings and type to be as follows:
 - a. Main/Branch Circuit Breakers in Type I Panelboards, and Main Circuit Breakers in Type II Panelboards and Lighting/Control Power Panelboards:
 - 1) Minimum U.L listed Symmetrical Current Interrupting rating (A.I.C. rating) at rated voltage shall be as shown and required by the PLANS.
 - 2) Panelboards shall be provided with high interrupting capacity or current limiter type breakers where necessary to withstand the available short circuit or limit it to a value which the downstream breakers can withstand.
 - 3) Provide current limiting circuit breakers where shown on the PLANS.
 - 4) Provide electronic trip attachment were shown on the PLANS. Trip unit shall be solid state type with field adjustable long time, short time, ground fault and pick up settings.
 - 5) Provide as manufactured by Square D Company Type FC, or approved equal by General Electric Company "G.E.", Cutler-Hammer Corporation.
 - b. Branch Circuit Breakers in Type II Panelboards:
 - 1) Minimum U.L listed Symmetrical Current Interrupting (A.I.C rating) at rated voltage shall be as shown and required by the PLANS for the panelboard main circuit breaker.
 - 2) Provide as manufactured by Square D Company Type EDB, or approved equal by General Electric Company "G.E.", Cutler-Hammer Corporation.
 - c. Branch Circuit Breakers in Lighting/Control Power Panelboards:
 - 1) U.L listed Symmetrical Current Interrupting 10,000 A.I.C. symmetrical at rated voltage.
 - 2) Provide as manufactured by Square D Company Type QOB, or approved equal by General Electric Company "G.E.", Cutler-Hammer Corporation.
 - d. Main and Branch circuit breakers in Mini-Power Centers:
 - 1) U.L listed Symmetrical Current Interrupting 10,000 A.I.C. symmetrical at rated voltage.
 - 2) Although required otherwise elsewhere, bolt-on type circuit breakers are not required for these assemblies.
 - 3) Provide as manufactured by Square D Company Type QO, or approved equal by General Electric Company "G.E.", Cutler-Hammer Corporation.

C. Miscellaneous Requirements

1. Integrated Equipment Rating: Each panelboard, as a complete unit, shall have a rating equal to or greater than the integrated equipment rating shown on the PLANS.
2. Provide a minimum of 20 percent spares on all panelboards and/or as shown on panel schedules on the attached Appendix A.

2.02 CABINET

- A. Adhere to the requirements of UL 50.
- B. Panelboard assemblies installed inside the Electrical Room
 1. Enclosure: NEMA-12, gasketed.
 2. Doors: Provide door-in-door type arrangement.

3. Finish: Primed and painted using the manufacturer's standard finishing process. Finish shall be applied at the manufacturing plant. Color shall be ANSI #61 Gray finish

C. Panelboard assemblies installed elsewhere:

1. Enclosure: NEMA-4X, Type 316 stainless steel, gasketed
2. Doors: Provide hinged doors complete with door handles.

D. A circuit directory in a metal frame with clear plastic covering shall be provided on the inside of the door. A directory card shall be typed to identify the load served by each circuit. Spare breakers shall be noted in pencil, however.

E. The panelboard interior assembly to be dead front with panelboard front removed. Main lugs or main breaker to be barrier on five sides. The end of the bus structure opposite the mains to be barriered.

2.03 NAMEPLATES

A. General:

1. Type: 3-ply, 1/8" thick, rigid thermoset phenolic resin laminated cellulose paper base engraving stock per ASTM D-709, Type I. Nameplates shall be ASTM Grade ES-1, ES-2, or ES-3 as applicable for the face and lettering colors specified hereinafter. Flexible or acrylic tags will be not be accepted
2. Color: White-Black-White
3. Lettering: 1/2 inch height, minimum, engraved through the face layer to the melamine middle layer.
4. Accessories: Provide holes for mechanical fastening.

2.04 SURGE PROTECTIVE DEVICE

A. Furnish and install Surge Protective Devices (SPD) where required by the PLANS. Each SPD shall have the following features:

1. Number of phases and system configuration (delta, wye grounded) to match and fully protect the bus to which the SPD is connected.
2. SPD shall be tested with the ANSI/IEEE Category C high exposure waveform of 10 kA for 8 x 20 microseconds, at minimum.
3. Visual indication of SPD status.
4. Surge counter.
5. Provide dry contact failure status output contact. Contact shall be rated for 120 volts A.C. and shall satisfy the requirements of the PLANS.

6. UL 1449.
7. 10 year minimum warranty.
8. SPD surge current withstand ratings shall be as follows:

| Panelboard Voltage | Minimum Current Withstand rating (Ampere per phase) | Minimum Current Withstand rating (Ampere per mode) |
|--------------------|---|--|
| 480 volts AC | 160kA | 80kA |
| 120/208 volts AC | 80kA | 40kA |

- B. Enclosure
 1. SPD located indoors in environmentally controlled rooms: NEMA 12
 2. SPD located outdoors or indoors in non-environmentally controlled rooms: NEMA 4X, Type 316 stainless steel.
- C. Manufacturer: Innovative Technologies Model PTX 120, Surge Suppression Inc. or approved equal.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install panelboards at the locations shown on the PLANS per the manufacturer's instructions and recommendations.
- B. Top of all panelboards shall be at no higher than 6 foot 0 inches above the finished floor elevation, unless specifically noted otherwise on the PLANS.
- C. Tagging:
 1. Tag equipment with the name as it appears on the PLANS using the specified nameplates. Panelboard nameplate shall also include: voltage ratings, phase, wire, ampere rating, AIC and withstand current rating, size and type of the main circuit breaker OR Main Lug Assembly (as applicable).
 2. Panelboards shall be provided with typed circuit schedule including circuit number, breaker rating and circuit description.
- D. Balance phases as closely as possible and type in directory at the close of the job. Use erasable pencil to indicate "Spares" and "Spaces".
- E. For surface mounting, use support channel per the requirements of Section 16150 "Raceways, Fittings and Supports" and per the details shown on the PLANS. For floor mounting, provide equipment pad as shown on the PLANS. Also refer to the details shown on the PLANS.
- F. Connect SPD per the requirements of the PLANS and in accordance with the SPD manufacturer's recommendations.

3.02 ISOLATED GROUND BUS APPLICATION

- A. Furnish and install an isolated ground bus in panelboard "FB1-CPP-001".

3.03 MEASUREMENT AND PAYMENT

- A. No separate measurement or payment for work performed under this Section. Include cost of same in Contract price bid for work of which this is a component part.

END OF SECTION

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**APPENDIX A -
SOUTH AUSTIN REGIONAL WWTP GRAVITY THICKENER IMPROVEMENTS
PANEL SCHEDULE**

| CIRCUIT BREAKER PANEL SCHEDULE - "GT-MPC-001" | | | | | | | | | | |
|--|--------------|----------|---|-------------|------------|-------------|---------------------------------------|-------------|--------------|--------------------------|
| VOLTS: 208/120 V BUS AMPS: 100 A MAIN: 100 A PHASE/WIRE: 3φ 4W | | | | | | | | | | |
| CONDUIT/WIRE DESCRIPTION | CKT BKR SIZE | CKT. NO. | LOAD DESCRIPTIONS | PHASE A | PHASE B | PHASE C | LOAD DESCRIPTIONS | CKT. NO. | CKT BKR SIZE | CONDUIT/WIRE DESCRIPTION |
| 1" - 2#10(P), 1#10(G) | 20 A 2 P | 1 | GRAVITY THICKENER SITE LIGHTING THRU CONTACTOR | 360 | | | GRAVITY THICKENER NO. 1A RECEPTACLES | 2 | 20 A 1 P | 1" - 2#8(P), 1#10(G) |
| | | | | 477 | | | | | | |
| 1" - 2#10(P), 1#10(G) | 20 A 2 P | 3 | GRAVITY THICKENER SITE LIGHTING THRU CONTACTOR | | 360 | | GRAVITY THICKENER NO. 2A RECEPTACLES | 4 | 20 A 1 P | 1" - 2#8(P), 1#10(G) |
| | | | | | 477 | | | | | |
| 1" - 2#8(P), 1#10(G) | 20 A 1 P | 5 | WEST ODOR CONTROL & BLENDING TANK TASK LIGHTING | | | 360 1462 | GRAVITY THICKENER NO. 1B RECEPTACLES | 6 | 20 A 1 P | 1" - 2#8(P), 1#10(G) |
| 1" - 2#8(P), 1#10(G) | 20 A 1 P | 7 | EAST ODOR CONTROL & BLENDING TANK TASK LIGHTING | 360 1170 | | | GRAVITY THICKENER NO. 2B RECEPTACLES | 8 | 20 A 1 P | 1" - 2#8(P), 1#10(G) |
| 1" - 2#10(P), 1#10(G) | 20 A 1 P | 9 | GRAVITY THICKENERS 1A & 2A INTERIOR LIGHTING | | 360 432 | | ODOR CONTROL NO. 1 RECEPTACLES | 10 | 20 A 1 P | 1" - 2#8(P), 1#10(G) |
| 1" - 2#10(P), 1#10(G) | 20 A 1 P | 11 | GRAVITY THICKENERS 1B & 2B INTERIOR LIGHTING | | | 360 432 | ODOR CONTROL NO. 2 RECEPTACLES | 12 | 20 A 1 P | 1" - 2#8(P), 1#10(G) |
| 3/4" - 2#10(P), 1#10(G) | 20 A 1 P | 13 | LIGHTING CONTACTOR "GT-LC-001" CONTROL POWER | 4160 100 | | | GRAVITY THICKENER WELDING RECEPTACLES | 14 | | 1" - 2#4(P), 1#8(G) |
| 3/4" - 3#10(P), 1#10(G) | 30 A 3 P | 15 | SURGE PROTECTIVE DEVICE "GT-SPD-MPC1" | | 4160 0 | | | 16 | 50 A 2 P | |
| | | 17 | | | | 0 0 | 18 | 20 A 1 P | | |
| | | 19 | | | | 0 0 | 20 | 20 A 1 P | | |
| | 20 A 1 P | 21 | SPARE | | 0 0 | | SPARE | 22 | 20 A 1 P | |
| | 20 A 1 P | 23 | SPARE | | | 0 0 | SPARE | 24 | 20 A 1 P | |
| TOTAL CONNECTED VOLT AMPS (VA) | | | | 6627 | 5789 | 2614 | | | | |

**APPENDIX A -
SOUTH AUSTIN REGIONAL WWTP GRAVITY THICKENER IMPROVEMENTS
PANEL SCHEDULE**

| CIRCUIT BREAKER PANEL SCHEDULE - "SGTL" | | | | | | | | | | |
|--|--------------|----------|----------------------------------|--------------|--------------|-------------|--|----------|--------------|--------------------------|
| VOLTS: 208/120 V BUS AMPS: 225 A MAIN: 225 A PHASE/WIRE: 3φ 4W | | | | | | | | | | |
| CONDUIT/WIRE DESCRIPTION | CKT BKR SIZE | CKT. NO. | LOAD DESCRIPTIONS | PHASE A | PHASE B | PHASE C | LOAD DESCRIPTIONS | CKT. NO. | CKT BKR SIZE | CONDUIT/WIRE DESCRIPTION |
| | 20 A 1 P | 1 | ELECTRICAL & PUMP ROOMS LIGHTING | 800 700 | | | RECEPTACLES WEST WALL & ELECTRICAL ROOM | 2 | 20 A 1 P | |
| | 20 A 1 P | 3 | ELECTRICAL & PUMP ROOMS LIGHTING | | 800 1500 | | RECEPTACLES NORTH WALL & ELECTRICAL ROOM | 4 | 20 A 1 P | |
| | 20 A 1 P | 5 | PUMP ROOM LIGHTING | | | 800 1200 | RECEPTACLES NORTH & SOUTH WALK | 6 | 20 A 1 P | |
| | 20 A 1 P | 7 | EMERGENCY LIGHTS | 1176 300 | | | OVERHEAD DOOR | 8 | 20 A 1 P | |
| | 20 A 1 P | 9 | COMMUNICATION SYSTEM | | 1200 1200 | | SUMP PUMP | 10 | 20 A 1 P | |
| | | 11 | | | | 200 4160 | "STP-2" MOTOR SPACE HEATER | 12 | 20 A 1 P | |
| | 50 A 2 P | 13 | WELDING RECEPTACLE | 100 4160 | | | FLOW TRANSMITTER | 14 | 20 A 1 P | |
| 3/4" - 2#10(P),1#10(G) | 20 A 1 P | 15 | "RIO2A" AUXILIARY POWER | | 0 180 | | | 16 | | |
| | | 17 | | | | 0 1800 | SPARE | 18 | 20 A 2 P | |
| | 30 A 3 P | 19 | OUTSIDE LIGHTS THRU CONTACTOR | 0 1800 | | | | 20 | | |
| | | 21 | | | 0 1800 | | SPARE | 22 | 20 A 2 P | |
| | 20 A 1 P | 23 | SUMP PUMP | | | 100 1200 | REMOTE CABINET | 24 | 20 A 1 P | |
| | 20 A 1 P | 25 | "PB-LIT-01A1" LEVEL DETECTOR | 1200 100 | | | SWITCHGEAR HEATER | 26 | 20 A 1 P | |
| 3/4" - 2#10(P),1#10(G) | 20 A 1 P | 27 | "STPB-CP-001" AUXILIARY POWER | | 100 180 | | "STA1-LIT-01A1" LEVEL DETECTOR | 28 | 20 A 1 P | |
| | 20 A 1 P | 29 | SPARE | | | 0 0 | | 30 | 0 A 1 P | |
| | 20 A 1 P | 31 | THICKENED SLUDGE PUMP NO. 1 | 1200 1200 | | | ANNUNCIATOR CABINET CONTROL PANEL | 32 | 20 A 1 P | |
| | 20 A 1 P | 33 | SPARE | | 100 0 | | "STB1-LIT-01A1" LEVEL DETECTOR | 34 | 20 A 1 P | |

CIRCUIT BREAKER PANEL SCHEDULE - "SGTL"

VOLTS: 208/120 V BUS AMPS: 225 A MAIN: 225 A PHASE/WIRE: 3φ 4W

| CONDUIT/WIRE DESCRIPTION | CKT BKR SIZE | CKT. NO. | LOAD DESCRIPTIONS | PHASE A | PHASE B | PHASE C | LOAD DESCRIPTIONS | CKT. NO. | CKT BKR SIZE | CONDUIT/WIRE DESCRIPTION |
|--------------------------------|--------------|----------|------------------------|---------|---------|---------|-------------------------------|----------|--------------|--------------------------|
| | 20 A 1 P | 35 | MSA GAS PANEL (INSIDE) | | | 100 | GAS DETECTION PANEL (OUTSIDE) | 36 | 20 A 1 P | |
| | | | | | | 100 | | | | |
| | | 37 | SPARE | 0 | | | | 38 | 0 A 1 P | |
| | | | | 0 | | | | | | |
| | 20 A 2 P | 39 | | | 0 | | | 40 | 0 A 1 P | |
| | | | | | 0 | | | | | |
| | 0 A 1 P | 41 | | | | 0 | | 42 | 0 A 1 P | |
| | | | | | | 0 | | | | |
| TOTAL CONNECTED VOLT AMPS (VA) | | | | 12736 | 7060 | 9660 | | | | |

**APPENDIX A -
SOUTH AUSTIN REGIONAL WWTP GRAVITY THICKENER IMPROVEMENTS
PANEL SCHEDULE**

| CIRCUIT BREAKER PANEL SCHEDULE - "STPB-CPP-001" | | | | | | | | | | |
|---|--------------|----------|--|---------|---------|---------|-------------------|----------|--------------|--------------------------|
| VOLTS: 208/120 V BUS AMPS: 100 A MAIN: 60 A PHASE/WIRE: 3φ 4W | | | | | | | | | | |
| CONDUIT/WIRE DESCRIPTION | CKT BKR SIZE | CKT. NO. | LOAD DESCRIPTIONS | PHASE A | PHASE B | PHASE C | LOAD DESCRIPTIONS | CKT. NO. | CKT BKR SIZE | CONDUIT/WIRE DESCRIPTION |
| 1" - 6#10(P),3#10(G) | 20 A 1 P | 1 | "RIO2A" UNINTERRUPTIBLE POWER SUPPLY | 0 0 | | | | 2 | 20 A 1 P | |
| INCLUDED IN CONDUIT WITH CIRCUIT NO. 1 | 20 A 1 P | 3 | "RIO2A" 24VDC POWER SUPPLY | | 0 0 | | | 4 | 20 A 1 P | |
| INCLUDED IN CONDUIT WITH CIRCUIT NO. 1 | 20 A 1 P | 5 | "RIO2A" SPARE CIRCUIT | | | 0 0 | | 6 | 20 A 1 P | |
| | 20 A 1 P | 7 | | 0 0 | | | | 8 | 20 A 1 P | |
| | 20 A 1 P | 9 | | | 0 0 | | | 10 | 20 A 1 P | |
| | 20 A 1 P | 11 | | | | 0 0 | | 12 | 20 A 1 P | |
| | 20 A 1 P | 13 | | 0 0 | | | | 14 | 20 A 1 P | |
| | 20 A 1 P | 15 | | | 0 0 | | | 16 | 20 A 1 P | |
| | 20 A 1 P | 17 | | | | 0 0 | | 18 | 20 A 1 P | |
| | 20 A 1 P | 19 | | 0 0 | | | | 20 | 20 A 1 P | |
| | 20 A 1 P | 21 | | | 0 0 | | | 22 | 20 A 1 P | |
| | 20 A 1 P | 23 | | | | 0 0 | | 24 | 20 A 1 P | |
| | 20 A 1 P | 25 | | 0 0 | | | | 26 | 20 A 1 P | |
| | 20 A 1 P | 27 | | | 0 0 | | | 28 | 20 A 1 P | |
| | 20 A 1 P | 29 | | | | 0 0 | | 30 | 20 A 1 P | |
| TOTAL CONNECTED VOLT AMPS (VA) | | | | 0 | 0 | 0 | | | | |

SECTION 16540
FIELD CONTROL STATIONS

PART 1 GENERAL

1.01 SCOPE

- A. Furnish and install field control stations as specified herein and as shown on the PLANS.

1.02 RELATED WORK NOT INCLUDED

- A. The PLANS designate the type and other requirements of the equipment specified in this Section.
- B. Related work as called for on the PLANS, as specified herein or in other Sections of the Specifications.

1.03 SUBMITTALS

- A. Submit shop drawings, product data, and layout drawings for the products of this Section in accordance with Section 01300 of the Specifications.
- B. Submit Operations and Maintenance Manuals (O&M) in accordance with Section 01730 of the Contract Specifications. O&M Manuals shall include copies of the approved shop drawings.

PART 2 PRODUCTS

2.01 PUSHBUTTONS, SELECTOR SWITCHES, PILOT LIGHTS

A. General Requirements:

1. Rating: NEMA 4X, corrosion resistant, Heavy Duty
2. Size: NEMA Style full size 30-millimeter (30mm),
3. Contacts: 10 ampere minimum at 120 volts A.C. Provide number of contacts to satisfy the requirements of the PLANS.
4. Legend Plate: Provide per manufacturer's standard with inscription as shown on the PLANS.
5. Manufacturer: Allen Bradley Bulletin 800H, or approved equal.

B. Additional Requirements for Selector Switch/ Pushbuttons:

1. Operator Color: Black, unless shown otherwise on the PLANS.
2. Selector Switch Action Type: Maintained action, unless shown otherwise on the PLANS.
3. Pushbutton Action Type: Momentary action, unless shown otherwise on the PLANS.

C. Additional Requirements for Pilot Lights:

1. Type: Transformer Type Light Emitting Diode (LED),
2. Voltage: 120 volts A.C.
3. Style: Push-to-test
4. Lens Color: Provide the colors as on the PLANS:

2.02 FIELD CONTROL STATION ENCLOSURE:

- A. Size: As required.
- B. Rating: NEMA-4X.
- C. Material: Type 316 Stainless Steel.
- D. All Field Control Station Enclosures shall have doors with quarter turn latches.
- E. Manufacturer: Allen-Bradley, Hoffman, Rittal, Millbank, or approved equal.

2.03 ROTATING BEACON AND HORN

A. Rotating Beacon

1. Application: Suitable for use outdoor installation in a corrosive environment
2. Type: Weatherproof rotating beacon light, rated NEMA-4X
3. Lens: Shatter resistant polycarbonate red lens
4. Base: Cast copper-free aluminum base. Suitable for outdoor installation and direct mounting on conduit or box.
5. Voltage: 120 VAC
6. Lamp: 100 Watt halogen
7. Revolution Speed: 75 revolutions per minute.
8. Certification: UL listed.
9. Accessories:
 - a. Aluminum wall mounting bracket as shown on the PLANS.
 - b. Four (4) spare lamps.
10. Manufacturer: Edwards Signal AdaptaBeacon 58R-N5-40WH, complete with wall mounting bracket model WBR, or approved equal.

B. Horn

1. Application: Suitable for use outdoor installation in a corrosive environment
2. Type: Weatherproof vibrating horn, rated NEMA-4X
3. Enclosure: Cast aluminum enclosure with epoxy powder finish. Enclosure shall be suitable for direct mounting on conduit or surface mounted on wall.
4. Voltage: 120 VAC
5. Output: Field adjustable output volume over the range of 88 to 113 dB, measured at 1 meter distance from the horn.
6. Certification: UL listed.
7. Manufacturer: Edwards Signal Vibrating Horn Model 876-N5, complete with wall mounting bracket model WBR, or approved equal.

2.04 DIGITAL INDICATORS

- A. Display Type: 4-digit, 1.0-inches high Liquid Crystal Diode (LCD) display, four digits and a floating decimal point.
- B. Process Variable Calibration: Engineering units (applicable to the specific system and measured variable) in order to indicate and control the process variable in the same units (i.e., GPM/MGD for Flow, Inches/Feet for Level, PSI for Pressure, °F/°C for Temperature, etc.). The engineering units shall be permanently marked on the surface of the indicators transmitters.
- C. Input Power: Two wire loop powered from the indicator input process variable signal.
- D. Accuracy: + / - 0.1 percent of calibrated span.
- E. Input Signal Type: 4-20mA proportional to the process variable measured.
- F. Enclosure: NEMA-4X corrosion resistant.
- G. Manufacturer: Precision Digital (microprocessor-based digital process meter) Model PD686 complete with Panel Mounting Kit PDA6844, or approved equal.

2.05 LEGEND PLATES/NAMEPLATES FOR CONTROL STATIONS

- A. General:
 1. Provide nameplates/legend plates for each control station, and each pilot device installed in a control station as shown on the PLANS and as previously specified.

B. Identification Nameplates:

1. General: Furnish and install identification nameplates for each field control station as follows unless shown otherwise on the PLANS:
 - a. Type: 3-ply, 1/8" thick, rigid thermoset phenolic resin laminated cellulose paper base engraving stock per ASTM D-709, Type I. Nameplates shall be ASTM Grade ES-1, ES-2, or ES-3 as applicable for the face and lettering colors specified hereinafter. Flexible or acrylic tags will be not be accepted.
 - b. Color: White-Black-White
 - c. Lettering: 1/4 inch height minimum unless shown otherwise on the PLANS, engraved through the face layer to the melamine middle layer.
 - d. Accessories: Provide holes for mechanical fastening
 - e. Attachment Means: Secured with two Stainless Steel screws.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Mount control stations as shown on the PLANS. Minimum mounting height shall be 3-foot 6-inches above finished floor unless shown otherwise on the PLANS. Secure stations firmly to support channels as specified in Section 16150 "Raceways, Fittings and Supports".

3.02 FIELD TESTING

- A. Perform field testing as required elsewhere.

3.03 MEASUREMENT AND TESTING

- A. No separate measurement or payment for work performed under this Section. Include cost of same in Contract price bid for work of which this is a component part:

END OF SECTION

SECTION 16550
GROUNDING

PART 1 GENERAL

1.01 SUMMARY

- A. Provide grounding in accordance with the PLANS, these Specifications and the National Electrical Code "N.E.C." Included within this section are furnishing and installing all the wire, connections, ground electrodes, and other devices associated with the grounding system associated with the aforementioned.

1.02 RELATED REQUIREMENTS

- A. Related work as called for on the PLANS, as specified herein or in other Division 16 Sections of the Specifications.

1.03 SUBMITTALS

- A. Submit shop drawings on all grounding system product and in accordance with Section 01300 of the Specifications.
- B. Submit Operations and Maintenance Manuals (O&M) in accordance with Section 01730 of the Specifications. O&M Manuals shall include copies of the approved shop drawings, and on-site/field test data.

PART 2 PRODUCTS

2.01 GENERAL

- A. Ground electrodes shall be minimally sized 24"x24", 16 gauge plates of high conductivity copper with molded pigtailed attached by the manufacturer. Ground electrodes shall be by Erico (Cadweld), or approved equal.
- B. Connections between ground electrodes and grounding electrode conductors shall be made below grade using Cadweld, Burndy Thermoweld, or equal thermite reaction welding system. Exception: Connections between ground electrodes and grounding electrode conductors made inside an accessible underground Grounding System Test Well, only where noted/detailed/shown on the PLANS, shall be permitted to be made with tin-plated Bolted Ground Lug connectors as manufactured by BURNDY Type GK , or approved equal.
- C. Grounding electrode conductors/wire shall be green insulated stranded copper. Use bare copper for grounding grids only (as shown on the PLANS).
- D. Equipment and/or static voltage and/or any other ground buses/bars (for any other type of use) called for on the PLANS and Specifications shall be tin-plated copper.

PART 3 EXECUTION

3.01 GENERAL:

- A. Connect each Ground Bus/bar directly to the Grounding Network conduit routed in the duct bank system in addition to the Grounding System around the manhole/handhole, as also shown on the PLANS.
- B. Extend a dedicated equipment ground wire, minimum size No. 6 AWG green insulated wire, from each Ground Bus/bar to each individual conduit system grounding bushings, each cable clamp, each support channel, etc. housed inside the associated electrical manhole/handhole. Also, refer to the PLANS
- C. Ground all electrical equipment, including lights and receptacles, etc., with a separate equipment ground wire installed in the conduit with the power conductors.
- D. Install grounding system electrically and mechanically continuous throughout. System neutral shall be bonded only at the building service transformer.
- E. Ground lighting transformer neutrals to their housing and bond the housing to the equipment grounding conductor.
- F. Connect equipment grounding conductors to ground bars or busses provided at panelboards, motor control centers, disconnect switches, switchgears, etc., from which the equipment is served.
- G. Where the equipment has no facility to attach an equipment ground wire, use a Burndy Quicklug or equal. Clean the metal surface under the lug to bright metal so that good contact can be made. Repaint metal surfaces after the lug and connecting ground wires are installed.
- H. Make ground connections to equipment by using ground lugs or ground bars, where they are provided.
- I. Use a thermite reaction welding system process as previously specified to make connections to ground electrodes; and, at any joint or connection which will be inaccessible after the construction. Exception: Connect to Grounding System Test Wells as previously specified and as also shown on the PLANS. Do not cover until each connection has been inspected by the Owner.
- J. Furnish bonding jumpers as shown or as otherwise required by the National Electrical Code "N.E.C." Use stranded copper wire.
- K. Inside buildings and at above ground level and through concrete floor slabs, route the ground wire(s) in a conduit raceway system. Fill annular space between ground wire and conduit with Crouse Hinds, Nelson or Raychem watertight and flame-retardant sealant.
- L. Connect ground wires entering outlet boxes in such a manner that removal of the receptacle will not interrupt the continuity of the grounding circuit. A grounding screw attached to the box, and used for no other purpose, may be used to accomplish this.

- M. Test grounding in accordance with Section 16800. Maximum resistance to ground shall not exceed 2-ohms. At no additional cost to the owner, install additional ground electrodes over the number required by the PLANS, as necessary to accomplish the 2-ohms or less resistance.
- N. Install a bonding jumper from the grounding lug of each Conduit-Grounding-Bushing to the ground bar or bus of each enclosure and/or equipment housing (such as pull boxes, junction boxes, panelboards, motor control centers, transformers, automatic transfer switches, instrument and control panels, etc.), as applicable. Instrument Grounds to be separate from power grounds. Instrument ground to be insulated up to the connection to the ground grid. Also refer to details shown on the Drawings. Bonding jumper wire for Conduit system Grounding-Bushings shall be STRANDED bare copper wire with minimum of 19-strands. Minimum wire size shall be #10 AWG.
- O. In each manhole/handhole:
 - 1. Mount a 400 amperes rated, tin-plated copper Ground Bus/bar of minimum length of 1-foot, unless shown otherwise on the PLANS.
 - 2. Mount ground bus on 600 volts AC stand-off isolators/insulators, as manufactured by Square-D Company or approved equal.
 - 3. Furnish each Ground Bus/bar with a minimum of six (6) terminals (ground lugs), unless shown otherwise on the PLANS. Each terminal (Grounding lug) shall be:
 - a. Tin-plated copper,
 - b. Cable of terminating wire from #10 AWG to #4 AWG
 - 4. Connect each Ground Bus/bar directly to the Grounding Network conduit routed in the duct bank system in addition to the Grounding System around the manhole/handhole, as also shown on the PLANS.
 - 5. Extend a dedicated equipment ground wire, minimum size No. 6 AWG green insulated wire, from each Ground Bus/bar to each individual conduit system grounding bushings, each cable clamp, each support channel, etc. housed inside the associated electrical manhole/handhole. Also, refer to the PLANS.

3.02 MEASUREMENT AND PAYMENT

- A. No separate measurement or payment for work performed under this Section. Include cost of same in Contract price bid for work of which this is a component part.

END OF SECTION

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SECTION 16600
DISCONNECT SWITCHES AND ENCLOSURES

PART 1 GENERAL

1.01 SUMMARY

- A. Furnish and install disconnect switches, enclosed circuit breakers, and manual motor starters as shown on the PLANS and specified herein.

1.02 RELATED REQUIREMENTS

- A. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
- B. It is the CONTRACTOR's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR's Work.
- C. The PLANS designate the size, rating, and other requirements of the equipment specified under this Section.
- D. Related work as called for on the PLANS, as specified herein or in other Sections of the Specifications.

1.03 SUBMITTALS

- A. Submit Shop Drawings in accordance with Section 01300 of the Contract Specifications. Include enclosure dimensions, ratings, wiring connection diagram and fabrication drawings. Submit protective device coordination curves and current limiting circuit breaker/fuse peak current let through curves, where applicable.
- B. Submit Operations and Maintenance Manuals (O&M) in accordance with Section 01730 of the Contract Specifications. O&M Manuals shall include copies of the approved shop drawings, and on-site/field test data.

PART 2 PRODUCTS

2.01 DISCONNECT SWITCHES

- A. Furnish and install Enclosed Circuit Breaker as hereinafter specified.

2.02 ENCLOSED CIRCUIT BREAKERS

- A. Construction:
 - 1. Molded case type, NEMA rated, and U.L. Listed.
 - 2. Circuit breakers shall have an overcenter, toggle handle-operated, trip free mechanism with quick make, quick break action independent of the speed of the toggle handle operation.

Breakers shall be thermal magnetic molded case type having inverse time thermal trip and instantaneous time magnetic trip. The design shall provide common tripping of all poles.

3. Circuit breaker shall have handles with provision for padlocking in the "OFF" position. The locking provisions shall be such that the padlock directly interferes with the operating handle and is fully visible. Circuit breakers shall have a dual enclosure interlock to prevent unauthorized opening of the enclosure door when the circuit breaker is in the "ON" position, or closing of the circuit breaker mechanism with the door open.
4. Furnish lugs to terminate the incoming/outgoing field wiring as shown on the PLANS. Refer to the PLANS. Additionally, provide a grounding lug for equipment ground wire connection. Lugs shall be U.L. listed.

B. Enclosures: NEMA-4X type 316 Stainless Steel gasketed cabinet

C. Circuit Breaker Ratings:

1. Voltage Ratings: 600 volts AC
2. Number of Phases: Three, unless shown otherwise on the PLANS.
3. Current Rating: Maximum continuous current carrying capacity shown on the PLANS
4. Minimum RMS symmetrical short circuit current rating: Equal to or greater than that of bus serving the circuit breaker at rated bus voltage A. C.
5. Breakers shall operate continuously when operating/running current is equal to 80% of the long time trip setting (or frame rating, as applicable) of the breakers.
6. Provide complete with rating plug and other accessories as required for proper operation of circuit breaker.
7. Furnish current limiting type circuit breakers when specifically required by the one-line drawings shown on the PLANS.
8. Provide electronic trip attachment where specifically shown on the PLANS. Trip unit shall be solid state type with adjustable long time, short time, instantaneous, ground fault and pick up settings as manufactured by "Square D" Micrologic LSIG Series B Trip Unit and Internal Ground Fault Protection, or approved equal.

D. Manufacturer: Circuit breakers shall be Square D Company Type FCL, General Electric Company "G.E.", Cutler-Hammer Corporation, or approved equal.

2.03 MANUAL MOTOR STARTERS

A. General

1. Type: Enclosed
2. Rating: NEMA size 1

3. Voltage Rating: 208 volts A.C.
4. Horsepower Rating: 7.5 HP
5. Number of Poles: Provide as required by the PLANS.
6. Operator: Pushbutton
7. Approvals: U.L. listed
8. Enclosure: NEMA 4X Type 316 Stainless Steel.
9. Accessories:
 - a. Thermal Overload Heater Element: Provide thermal overload heater elements as required. Size per NEC
 - b. Red "On" indicating pilot light wired per manufacturer's standard.
10. Manufacturer: Square D, Class 2510 Type M, Cutler-Hammer, General Electric Company "G.E.", or approved equal.

2.04 IDENTIFICATION

A. General:

1. Furnish and install identification nameplates for each piece of equipment as follows:
 - a. Type: 3-ply, 1/8" thick, rigid thermoset phenolic resin laminated cellulose paper base engraving stock per ASTM D-709, Type I. Nameplates shall be ASTM Grade ES-1, ES-2, or ES-3 as applicable for the face and lettering colors specified hereinafter. Flexible or acrylic tags will be not be accepted.
 - b. Color: White-Black-White
 - c. Lettering: 1/4 inch height, minimum, engraved through the face layer to the melamine middle layer.
 - d. Accessories: Provide holes for mechanical fastening
 - e. Attachment Means: Secured with two Stainless Steel screws.
2. Exception: Identify manual motor starters mounted in environmentally controlled rooms as specified in Section 16300 "Wiring Devices".

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install where the top of each enclosure is no higher than 6-feet-6-inches above the finished floor elevation, unless otherwise noted on the PLANS.
- B. Surface mount on support channels per the requirements Section 16150 "Raceways, Fittings and Supports" and the details shown on the PLANS. Also refer to details shown on the PLANS.
- C. Tag equipment with the name as it appears on the PLANS using the specified nameplates.

3.02 MEASUREMENT AND PAYMENT

- A. No separate measurement or payment for work performed under this Section. Include cost of same in Contract price bid for work of which this is a component part.

END OF SECTION

SECTION 16800
CALIBRATION, TESTING AND SETTINGS

PART 1 GENERAL

1.01 SUMMARY

- A. Provide all equipment and labor required for calibration, setting and testing as described herein or otherwise required. All tests shall be witnessed by the OWNER or the OWNER's designated representative. Give written notification of the tests at least seven days prior to the desired date to perform the tests. Repair or replace all defective material, equipment or workmanship disclosed as a result of these tests at no cost to OWNER.
- B. All work, including installation, connection, calibration, testing, and adjustment, shall be accomplished by qualified, experienced personnel working under continuous, competent supervision. The completed installation shall display competent work, reflecting adherence to prevailing industrial standards and methods.
- C. Tests: The Contractor shall make all tests required by these specifications, or other authorities having jurisdictions. All such tests shall be performed in the presence of the Construction Manager or his representative. The Contractor shall furnish all necessary testing equipment and pay all costs of tests, including all replacement parts and labor necessary due to damage resulting from damaged equipment or from test and correction of faulty installation.

1.02 SUBMITTALS

- A. Submittals shall include copies of the test results/reports. Submittals shall be per the quantity and format requirements of Section 01300 and 01730 of the Specifications. Include the following at minimum:
 - 1. Test results, inclusive of catalog number/drawing cross-reference, where applicable, and any other data entered on the field test report
 - 2. Testing Plans
 - 3. All test instrument data sheets and calibration certificates

1.03 TEST PLAN AND TEST RESULTS

- A. Performance: Testing shall be performed in compliance with the approved Test Plan. The Test Plan shall be submitted in accordance with the outline given below. Provide the OWNER with typewritten results of all tests, including a description of the equipment tested, the date and time of day tested, names of witnesses, weather conditions; and test values and results.
- B. Test plan: At minimum, Submit a Test Plan for each of the Sections listed in Division 16 of these specifications. Test Plan shall be submitted at least two(2) weeks prior to the desired date and time of the test. Test Plan shall clearly identify the following, as applicable:
 - 1. Desired date and time to perform the test
 - 2. Name of Entity/individual that shall perform the test

3. Test procedures and recording data sheets
4. Name, description, catalog number, calibration date, and calibration entity's name of each of the test instruments to be used in executing the test
5. Expected duration of the test
6. Request for type, time and duration of any shutdown that may be required during the test.

C. Test Results:

Submit Test Results for each of the Sections listed in Division 16 of these specifications. Test Results shall be submitted no later than at least two (2) weeks after the last date of the respective test. Test Results shall be typewritten and shall include the following, as minimum:

1. All data and information provided in the Test Plan
2. Name of Entities and individuals that attended and witnessed the test
3. Weather Conditions
4. Tabulated test values and results
5. Corrective measures taken and/or to be taken toward defective material, equipment or workmanship disclosed as a result of these tests. Also include Re-Test dates and procedures for defective material, equipment or workmanship disclosed from the previous test.

1.04 TEST EQUIPMENT

- A. Each test instrument shall have been certified by an established calibration laboratory within the six (6) months prior to its use in testing and calibration procedures. Calibration shall be traceable to the National Institute of Standards and Technology (NIST).

PART 2 PRODUCTS

- A. No products are required by this Section of the Specifications.

PART 3 EXECUTION

3.01 INSULATION RESISTANCE (MEGGER) TESTS:

- A. Use a minimum 500 volt megohmmeter.
- B. Take each reading for at least one minute.

C. Include the following tests:

| <u>Equipment</u> | <u>Minimum Resistance</u> |
|--------------------------------|---------------------------|
| 115 and 230 volt motors | 5.0 Megohms |
| 460 volt motors | 7.0 Megohms |
| 4000 volt motors | 10.0 Megohms |
| 600 volt transformer winding | 100.0 Megohms |
| 600 volt wiring up to 1000 ft. | 25.0 Megohms |

Coordinate minimum values shown with equipment manufacturer's recommendations.

D. Test all transformer windings as follows:

1. Primary to ground
2. Secondary to ground
3. Primary to secondary

E. Record and submit all Megger readings to the OWNER/ENGINEER for review and record keeping purposes. Neatly type all readings and organize in a Database table form. Incremental megger readings shall also be recorded and included in the table.

3.02 GROUND TEST

- A. Ground System testing shall be performed by an independent professional testing company specialized in, and well equipped to perform, ground resistance testing.
- B. Ground testing shall assure resistance to ground values listed in the Grounding Specification. All tests must be witnessed by the Owner or the Owner's designated representative.
- C. At a minimum, test each of the following separately, with ground under test isolated from other grounds:
 1. Each process area/building grounding network, i.e., WRI Fill Station, etc. Furnish and install additional grounding/ground electrodes if the resistance to ground measures more than the values stipulated in the Grounding Section of the Specifications. This shall be executed at no additional cost to the Owner.
 2. Each manhole.
 3. Each handhole.

- D. Finally, after all tests of each individual process area/building, manhole, handhole, etc., are performed as previously specified, perform a final test after all of the individual process areas/buildings, manholes, handholes, etc. grounding networks are interconnected as also shown on the PLANS.

3.03 MOTORS

- A. Test the insulation resistance (megger test) of all motors installed under this Contract inclusive of process mechanical drive motors and the Heating and Ventilation System drive motors such as exhaust fans, fan and coil units drive motors, etc. Test all motors in accordance to with subsection 3.01 above.
- B. Dry out any wet insulation by use of space heaters or other approved methods.
- C. Check coupling alignment, shaft end play, lubrication, and other mechanical checks as required. Follow manufacturer's instructions.
- D. Check for proper motor rotation.

3.04 RECEPTACLES

Test all receptacles for proper connections and grounding. Use an approved plug-in tester equal to Woodhead 1750 or Hubbell 5200.

3.05 CONTROL CIRCUITS

- A. Check all circuits for continuity, proper connection, and proper operations.
- B. Set all time delay relays and timers for the desired operations. Record the settings, indicating the relay or timer, its location, and the setting used. Verify all settings with a stopwatch.

3.06 CONTINUITY TESTS

- A. Perform continuity test on all low voltage conductors (600 volt, and below, wiring system). Continuity test must be performed after wiring is pulled in the conduit system and/or underground electrical system (as applicable). Continuity test must be performed on each conductor between its source and final destination (point of termination to load/device/etc.). Utilize Ohmmeter for this test. Ohmmeter must be set to lowest ohm setting (highest resolution).

3.07 MEASUREMENT AND PAYMENT

- A. No separate measurement or payment for work performed under this Section. Include cost of same in Contract price bid for work of which this is a component part.

END OF SECTION

SECTION 17100
PROCESS INSTRUMENTATION AND CONTROL SYSTEMS PICS

PART 1 GENERAL

1.01 SUMMARY

- A. Provide all labor, materials, and equipment to design, furnish, install, calibrate, test, adjust, and place in operation the facility complete monitoring and control system as specified herein and as shown on the PLANS. The PLANS and Specifications show and specify those features required to illustrate and describe functional requirements of the monitoring and control system.
- B. A single Instrument and Control System Contractor (ICS) shall furnish all services and equipment defined herein and in other Specification sections as listed below under Related Work. The Instrument and Control System Contractor is referred to herein and after (in Division 17 of the Specifications) as the ICS, ICS supplier/firm, or Contractor. The ICS shall have the qualifications as described in subsection 2.0, "Quality Assurance", this Section of the Specifications, as well as those described in Section 00400.
- C. The ICS shall also:
 - 1. Terminate and tag all field wiring associated with the process instrumentation and control system shown on the PLANS and specified herein and in other Specification sections listed below under Related Work.
 - 2. Tag Instrumentation and control wiring/cable per the requirements and methodology/scheme outlined in specifications Section 16200 "Wiring (600 volt and Below) paragraph 3.03 "Wire Tagging Methodology".
 - 3. Calibrate, set and test the PICS equipment, components, cables, hardware, and software.
 - 4. For equipment and ancillaries required under PICS Subsystem sections:
 - a. Required submittals.
 - b. Equipment and ancillaries.
 - c. Instructions, details, and recommendations to, and coordination with, all other installation entities for Certificate of Proper Installation.
 - d. Certifying readiness for operation.
 - e. Starting up.
 - f. Testing.
 - g. Training
 - h. Use of testing/calibration equipment to facilitate calibration/testing of field sensors and instruments. Equipment shall include, but not be limited to:
 - 1) Test pressure pump for field calibration/testing of pressure transmitters.
 - 2) Signal generator/multi-function meter for field calibration/testing of resistance temperature detector (RTD) monitoring devices
 - 3) Temperature/heat generator for field calibration/testing of temperature transmitters.
 - 5. Provide special additional services during installation, including:
 - a. Verifying that the following are furnished and installed:
 - 1) Correct type size, and number of signal wires with their raceways.

- 2) Correct electrical power circuits and raceways.
- 3) Correct size, type, and number of PICS related pipes, valves, fittings, and tubes.
- 4) Correct size, type, materials, and connections of process mechanical piping for in-line primary elements
- b. For equipment not provided by the ICS, but directly connected to the PICS:
 - 1) Obtain manufacturer's information regarding installation, interface, function, and adjustment for equipment from the Contractor.
 - 2) Coordinate with Contractor to allow required interface and operation with the PICS.
 - 3) Verify that installation, interfacing signal terminations, calibration, and adjustments have been completed in accordance with the manufacturer's recommendations.
 - 4) Test to demonstrate the required interface and operation with the PICS.
 - 5) Examples of equipment in this category include, but are not limited to the following:
 - a) OWNER's Top-End Computer System
 - b) Motorized Valve Operators
 - c) Motor Control Centers
 - d) Process/Mechanical Equipment.
6. Provide equipment and delivery of the DCS configuration system to the ENGINEER's Austin, Texas office.
7. Assist OWNER/ENGINEER, as specified in applicable DCS subsystem specifications sections, in the PAT testing of the Applications Software which shall be developed by OWNER/ENGINEER for the DCS and Laptop Computer (as applicable).
- D. As shown on the PLANS, the Gravity Thickener Building is networked with the Owner's existing plant Top-End computer system as well as other existing DCS equipment at the Gravity Thickener Building. Refer to the PLANS. Effort is required of the ICS to establish a functional and complete communication network link between the proposed equipment of this project, the existing DCS equipment at the Gravity Thickener Building, and the Owner's existing plant Top-End computer system in order to achieve proper and complete system operation. This effort shall include, but not be limited to:
 1. Coordination with all responsible parties, i.e. Owner, manufacturers, etc., to facilitate proper communication equipment selection, cable termination connector quantities/types, patch panel locations in controls panels to address minimum cable bending radius, etc., as required
 2. System startup testing, diagnosing, and resolving communication system issues, etc.
- E. Extensive field verification is required for all modifications to existing control panels. The ICS shall include effort associated with field verifying spatial dimensions inside the existing control panels for proposed equipment, wiring terminations, loop power supply sizes, loads on existing instrument loops, points of connections to existing equipment, etc. as required to support the proposed modification effort associated with this project. The ICS shall field locate proposed equipment to be installed inside the existing control panel as also shown on the PLANS. The proposed location shall be coordinated with the arrangement of the existing control panel internal and externally mounted components.

- F. The Owner's existing distributed control system is vital to the Owner's waste-water treatment plant process system. Therefore, required interruptions to the Owner's existing distributed control system shall be minimized and coordinated with the Owner. Regarding interruptions, refer to and comply with the General Notes shown on the Electrical as well as the Instrumentation and Control series of PLANS. Also refer to the PLANS and other Specification Sections for additional requirements.
- G. The Owner's existing distributed control system equipment and its associated interconnect wiring, power supplies, fuses, etc., is in perfect working condition. Should the existing equipment, its associated interconnect wiring, power supplies, fuses, etc., as applicable, be damaged or become otherwise unusable during the construction course of this project, the ICS shall determine the problem, correct it, and furnish and install all necessary wiring/hardware/etc., to match existing and make all final connections such that all affected equipment operates as previously operated to the Owner's satisfaction at No Additional Cost to the Owner.

1.02 RELATED REQUIREMENTS

- A. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
- B. It is the CONTRACTOR's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR's Work.
- C. Division-16 ELECTRICAL SPECIFICATIONS
- D. Division-17: INSTRUMENTATION AND CONTROL SPECIFICATIONS
- E. All other division of the Specifications related to the installation of the process mechanical equipment, etc. that are related to the operation of the instrumentation and control system.
- F. Related work as called for on the PLANS, as specified herein or in other Sections of the Specifications.

1.03 SUBMITTALS

- A. General: Do not design, manufacture, or ship any PICS equipment until all related submittals have been reviewed and approved by the ENGINEER. Submit shop drawings and product data in complete functional packages; i.e., submit all shop drawings and product data for a given loop or subsystem together as a functional package. Piecemeal submittals not organized by systems or incomplete submittals for a given loop or subsystem will not be accepted.
- B. Administrative Submittals:
 - 1. Schedule of Values
 - a. Purpose: Project Schedule of Values to provide a basis for Partial Payment for Work completed.
 - b. Content: Summary of major milestones and associated Partial Payments for Work provided under PICS Subsystems.

2. PICS Progress schedule
 - a. Purpose: Supplement the overall Project Progress Schedule to:
 - 1) Coordinate activities between the Contractor and the ICS
 - 2) Coordinate interactions with the OWNER/ENGINEER for coordination meetings, submittal reviews, etc.
 - 3) Clarify required work sequences and major milestone prerequisites.
 - b. Provide multiple submittals of the project schedule throughout the duration of the Project as required.
 3. OWNER Training Plan: Submit description/schedule of OWNER Training to be provided.
 4. Statements of Qualification: Submit for PICS firm, site representative, start-up and testing team member.
- C. Submit shop drawings in accordance with Section 01300 of the Specifications and as specified below:
1. Detailed product data, catalog cut sheets, cabinet exterior and interior front elevations, bill of materials, and spare parts list
 2. Point-to-Point Wiring Diagrams: Prepare Point-to-Point Instrument Loop Wiring Diagrams, ladder diagrams (control schematics), cabinet wiring, and other field wiring diagrams in accordance to the format shown on the PLANS. Drawings shall be neat, and legible, and on 11 inch x 17 inch sized sheets. Drawings to include all relevant information for equipment connected to the PICS, regardless if the equipment is provided by the ICS or not, i.e., include motor control centers, OWNER pre-purchased equipment, etc. Contractor shall also submit for approval a complete schedule of all wire tag numbers sorted by area and equipment/instrument/field device.
 3. Although typical control schematics/instrument loops are presented on the PLANS for some equipment, the Contractor shall generate specific equipment control schematic drawings/instrument loops (i.e., individual control schematic/instrument loop drawings dedicated for each specific equipment) based upon the typical control schematic/instrument loop drawings, the device identification/tag replacement schedules shown on the PLANS, and the additional requirements described herein. The Contractor generated specific equipment control schematics/instrument loops shall follow the same overall presentation format as the typical equipment control schematics/instrument loops presented on the PLANS. The specific equipment control schematics/instrument loop drawings, complete with all specific equipment/device tags (as a minimum, also refer to the additional requirements described herein) shall be generated by the Contractor and included with the project submittals (i.e., prior to equipment purchase) and the "As-Built" drawings. Any Contractor generated control schematic/instrument loop shown as applicable to multiple equipment shall not be accepted.
- D. Testing Related Submittals:
1. Submit factory and field calibration reports
 2. Submit the following for each of type of test (ORT and PAT) required under Division 17 of the Specifications:
 - a. Preliminary Test Procedures: Outlines of proposed tests, forms, and checklists.

- b. Final Test Procedures: Proposed test procedures, forms, and checklists.
 - c. Test Documentation: Copy of signed off test procedures when tests are completed.
- E. Training Related Submittals:
- 1. Submit the following for each type of training required under Division 17 of the Specifications:
 - a. Training plan, course topics, subjects to be addressed in the training
 - b. Schedule
 - c. Training agenda for each course
 - d. Instructor qualifications
 - e. Listing of available training courses and outline of course topics and agendas
- F. Submit Operation and Maintenance manuals in accordance with Section 01300 and 01730 of the Specifications and as specified below:
- 1. Include approved shop drawing data in the Operation and Maintenance manuals with the following modifications to the shop drawing exhibits:
 - a. Reflect "As-Built" conditions.
 - b. Prints of exhibits, wiring diagrams, etc. shall be half size (11 inch by 17 inch).
 - 2. Procedures for operating and shut-down
 - 3. Included approved Testing Related Submittals with final "As-Built" conditions.
 - 4. Safety instructions.
 - 5. Calibration instructions and factory test results of each instrument.
 - 6. Maintenance and repair instructions.
 - 7. Recommended spare parts list.
 - 8. Name, address and phone number of instrumentation control system supplier's local representative.
 - 9. Additionally, comply with the requirements of the Contract Documents.
- G. Pre-submittal conference
- 1. General:
 - a. Review the manner in which the contract requirements will be met prior to preparation of submittals. The Contractor, Engineer, Owner, and ICS shall attend. Schedule, conduct, and arrange the conference within 90 calendar days after receipt of written notice to proceed work is given by the Owner.
 - b. The ICS shall present the following at the conference:
 - 1) List of equipment and materials required and the brand that shall be used for each item
 - 2) Sample submittals from similar projects including the types of drawings/data/lists specified herein

1.04 SPECIAL CONDITIONS

- A. All components used in the instrument and control systems shall be new (not used) and the current model produced by the manufacturer.
- B. All equipment of a common type shall be the product of a single manufacturer.

PART 2 QUALITY ASSURANCE

2.01 ACCEPTABLE PROCESS INSTRUMENTATION AND CONTROL SYSTEM PICS

- A. Provide a complete, workable, and installed-in-place Process Instrument and Control System, hereinafter referred to as the PICS, as specified herein. The PICS shall be designed, installed, and started up by the single ICS firm.
- B. Acceptable ICS firm shall have the following minimum qualifications:
 - 1. ICS Firm: Minimum of 5 years experience in providing, integrating, installing, testing, and start-up similar systems as those required for this project
 - 2. ICS Firm Site Representative: Minimum of 8 years experience installing similar systems as those required for this project
 - 3. ICS Firm Start-up and Testing Team Members: Minimum of 3 years experience in testing systems similar to those required for this project.
- C. PICS meetings to be scheduled in accordance with the Contract Documents.

2.02 SYSTEM COORDINATION AND QUALITY

- A. Coordinate installation of instrumentation with mechanical and electrical systems.
- B. Coordinate subsystems to provide a complete operational and functional instrumentation system to the satisfaction of the OWNER and ENGINEER.
- C. Equipment, instruments, components, and materials for PICS components shall be new (not used) and of the current model.
- D. Instrument and Control Components Furnished By Others: Certain items of instrumentation and controls shall be furnished by various equipment manufacturers. Coordinate the purchase orders of the items such that the resulting system will function properly.

2.03 DESIGN CRITERIA

- A. Design, construct, and install all PICS components in compliance with the applicable provisions of the following standards, codes, and regulations:
 - 1. American National Standards Institute (ANSI) Standards.
 - 2. American Institute of Steel Construction (AISC) Standards.
 - 3. American Society for Testing and Materials (ASTM) Standards.

4. American Waterworks Association (AWWA) Standards.
5. Joint Industrial Council (JIC) Standards.
6. National Electric Code (NEC)
7. National Electrical Manufacturer's Association (NEMA) Standards.
8. Local and State Building Codes.
9. Occupational Safety and Health Administration (OSHA) Regulations.
10. Scientific Apparatus Manufacturer's Association (SAMA) Standards.
11. Instrument Society of American Standards (ISA).
12. National Fire Protection Association (NFPA)
13. Institute of Electrical and Electronics Engineers (IEEE).

2.04 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Delivery: Enclose cabinets and subassemblies in heavy polyethylene envelopes to protect them from dust and moisture. Place corrosive-inhibitive vapor capsules in shipping containers, and related equipment as recommended by the capsule manufacturer.
- B. Storage: All materials and equipment shall be environmentally protected and stored in climate controlled (temperature and humidity, etc.) environment. The Instrument Control Panels and the field control and instrument/monitoring panels shall not be moved from climate controlled storage room to the project site until the construction of each electrical/control room is completed, and, the air-conditioning and heating system of the facility is in an operating condition satisfactory to the OWNER and ENGINEER.
- C. Additional project job site storage requirements: Upon delivery to the project site and prior to final installation, protect and store in accordance with the following:
 1. Environmentally protected and stored in climate controlled (temperature, humidity, and non-corrosive class) environment at the job site. Size, furnish and install temporary gaseous air scrubbers, air conditioners, and additional environmental control equipment complete with branch circuiting conduit/wire as required to maintain in a controlled environment at the following conditions:
 - a. Ambient Dry Bulb Temperature:
 - 1) Minimum: 68 degrees Fahrenheit.
 - 2) Maximum: 85 degrees Fahrenheit.
 - b. Ambient Relative Humidity: Maximum: 50%.
 - c. Ambient Corrosion Level: International Society of Automation Class: G1
 2. Every effort shall be made to provide all necessary electrical power connections ready for immediate connection to equipment upon arrival of equipment on jobsite.

3. Upon arrival of equipment onto job site, the contractor shall provide proper transition of power to equipment, especially any 120 VAC powered equipment, to ensure all air conditioning, heating, and gaseous air scrubbing equipment are fully operational and that the equipment is in a conditioned space on the day the equipment arrives.
4. Furnish and install replacement air scrubber media, air filters, etc., as required for proper operation of the environmental control equipment.

2.05 CALIBRATION INSTRUMENTS

- A. Each instrument used for calibrating PICS equipment shall bear the seal of a reputable laboratory certifying that instrument has been calibrated within the previous twelve (12) months to a standard endorsed by the National Institute of Standards and Technology (NIST). At OWNER's request, ICS shall submit calibration certification report.

2.06 START DATE OF THE PROCESS INSTRUMENTATION AND CONTROL SYSTEM AND ASSOCIATED SUBSYSTEM WARRANTY (PICS INCLUDING SUBSYSTEMS)

- A. Start Date of the process instrumentation and control system and associated subsystem Warranty (PICS including Subsystems) shall commence the date in which the Warranty period commences for the overall project per the requirements of the Contract Documents.

PART 3 SEQUENCING AND SCHEDULING

3.01 GENERAL

- A. All work provided under this section shall be in accordance with the OWNER/ENGINEER-approved Schedule of Submittal Submissions and Schedule of Values.
- B. Specification and Construction Implementation Plan requires phased installation of equipment and systems. Stage all PICS activities (submittals, fabrication, installation, testing, start-up, training, etc.) to support the construction sequencing requirements of the project.
- C. Wherever language in this section refers to the PICS, the entire installed PICS, the entire PICS, or similar language, it shall be interpreted to apply to the individual phases of the work; except the requirements for the Performance Acceptance Test (PAT).
- D. Key milestone dates associated with PICS activity shall be included in the overall project schedule. Include the following dates as a minimum:
 1. ORT start and end date
 2. PAT start and end date
 3. Date Configuration System is delivered to the Engineer
 4. Date Configuration System is expected to be retrieved from the Engineer.
 5. Training dates

3.02 PREREQUISITE ACTIVITIES AND LEAD TIMES:

- A. Start the following key Project activities when prerequisite activities and lead times listed below have been completed and satisfied:
1. Shop Drawings submittal prerequisite: Completion of the Pre-submittal conference
 2. Test Prerequisite:
 - a. All associated process and mechanical equipment, controlled and monitored by the instrumentation and control system, complete in place
 - b. Associated test plan submittal completed. For ORT and PAT, notice of test schedule required 4 weeks prior to the start of test
 3. ORT Prerequisite:
 - a. Approved ORT test procedures
 - b. Approved ORT test forms
 - c. 30 calendar days advance written notice to given to Owner of impending ORT.
 4. PAT Prerequisite:
 - a. Six (6) months minimum elapsed time after delivery of Configuration System to Engineer's office.
 - b. ORT successfully completed.
 - c. Approved PAT test procedures
 - d. 30 calendar days advance written notice to given to Owner of impending PAT.
 5. O&M submittal prerequisite: PAT successfully completed.
- B. Configuration System Delivery: Deliver the entire Configuration System to the Engineer's office no later than 90 days after the completion of the Pre-Submittal Conference.

PART 4 PRODUCTS

4.01 GENERAL

Refer to requirements of PICS Subsystem provided in Division-17 Specifications.

4.02 SOURCE QUALITY CONTROL

- A. General:
1. Test all PICS elements, both hardware and specific software, to demonstrate that PICS satisfies all requirements.
 2. On-Site Tests Described Under PART 3 - EXECUTION:
 - a. Operational Readiness Test "ORT"
 - b. Performance Acceptance Tests "PAT".
 3. Test Format: Cause and effect
 - a. Person conducting test inivates an input (cause)
 - b. Specific test requirement is satisfied if the correct result (effect) occurs

4. Procedures, Forms, and Checklists:
 - a. Conduct all tests in accordance with, and documented on, ENGINEER accepted procedures, forms, and checklists.
 - b. Describe each test item to be performed.
 - c. Have space after each test item description for sign off by appropriate party after satisfactory completion.
 5. Required Test Documentation: Test procedures, forms, and checklists. All signed by OWNER/ENGINEER and Contractor.
 6. Conducting Tests:
 - a. All special testing materials and equipment.
 - b. Wherever possible, perform tests using actual process variables, equipment, and data.
 - c. If it is not practical to test with real process variables, equipment, and data, provide suitable means of simulation.
 - d. Define simulation techniques in test procedures
 - e. For PICS Subsystems for which OWNER provides applications software, provide sufficient temporary software configuring to allow for ORT testing of these subsystems.
 7. OWNER/ENGINEER will actively participate in many of the tests.
 8. OWNER/ENGINEER reserves the right to test or retest all specified functions whether or not explicitly stated in the Test Procedures.
 9. OWNER's/ENGINEER's decision will be final regarding acceptability and completeness of all testing.
- B. Maintenance of Configuration System (as defined in Section 17600 "Distributed Control System):
1. Provide for maintenance of the Configuration System at the ENGINEER's office. Repair or replace failed equipment within two days of notice by ENGINEER..
- C. Provide field support during Owner/Engineer testing of installed applications software

PART 5 EXECUTION

5.01 EXAMINATION

- A. Equipment furnished by Supplier or any other subcontractor and installed by the ICS/Contractor, requires Supplier to observe and advise on installation to extent required to certify that equipment has been properly installed and will perform as required.
- B. For equipment not provided by the ICS, but that directly interfaces with the PICS, verify the following conditions:
 1. Proper installation.
 2. Calibration and adjustment of all instrumentation and control devices.

3. Correct control action.
4. Switch settings.
5. Opening and closing speeds and travel stops.
6. Input and output signals.

5.02 INSTALLATION

A. Material and Equipment Installation:

1. Follow manufacturer's installation instructions, unless otherwise indicated or directed by the OWNER/ENGINEER
2. Retain a copy of the manufacturer's instructions at the project site, available for review at all times.

B. Wiring:

1. All wiring connected to PICS components and assemblies shall be in accordance to the requirements of Division 16 and 17 of the Specifications.

5.03 FIELD QUALITY CONTROL

A. General: All requirements listed in Subsection Source Quality Control, above, also apply to this Subsection, Field Quality Control.

B. Onsite Supervision:

1. The ICS Project Site Representative shall supervise and coordinate all onsite PICS activities.
2. The ICS Project Site Representative shall be On-Site during total period required to complete all On-Site PICS activities.

C. Startup and Testing Team:

1. Thoroughly check installation, termination, and adjustment for all PICS Subsystems and their components.
2. Completed On-Site tests.
3. Provide and conduct startup services
4. Complete onsite training.

D. Sequence of Work: Provide individual ORTs and PATs for individual process equipment where required to support the staged construction and startup of the facility. Closely and carefully coordinate the construction sequencing requirements with the OWNER.

- E. Specialty Equipment: For certain components or systems provided under this Section but not manufactured by the ICS, provide services of qualified manufacturer's representative during installation, start-up, testing (both ORT and PAT) and OWNER's training. For example: RTD calibrator, vibration shaker table (which may be furnished/operated by vibration sensor manufacturer representative), pressure calibrator, etc, shall be provided as required.
- F. Operational Readiness Test (ORT):
1. Prior to start of the Performance Acceptance Test "PAT", the ICS firm shall inspect, test the PICS equipment and systems, document the resulting tests performed, implement all corrective actions necessary, perform all associated re-testing, and document that the PICS is installed and ready for operation. Subsequent to the ICS documentation that the PICS is installed and ready for operation, perform jointly with the OWNER an ORT on the associated PICS equipment to demonstrate that it is fully operable as required by the Contract Documents.
 2. For PICS subsystems where the PLC application software is provided by the OWNER, provide sufficient temporary software configuring to allow testing of these subsystems.
 3. Loop/Component Inspections and Tests:
 - a. Check PICS for proper installation, calibration, and adjustment on a loop-by-loop, and component-by-component basis.
 - b. Develop and provide forms as required to document ORT. All forms generated shall have provisions for signature by PICS representative.
 - c. Develop and provide test form hereinafter called the "Loop Status Report" to organize, track inspection, adjustment, and calibration of each loop. Loop Status Report shall include the following as a minimum:
 - 1) Project name
 - 2) Loop number
 - 3) Tag number for each component
 - 4) Checkoff/signoffs for each component:
 - a) Tag/identification
 - b) Installation
 - c) Wiring termination
 - d) Tubing termination
 - e) Calibration/adjustment
 - 5) Checkoffs/signoffs for each loop:
 - a) Panel interface termination
 - b) PLC I/O interface terminations
 - 6) PLC I/O Signals are Operational: Received/sent, processed, adjusted
 - 7) Total loop operational
 - 8) Space for comments.
 - d. Develop and provide test form hereinafter called the "Component Calibration Sheet" to organize, track inspection, adjustment, and calibration of each component (except hand switches, pilot lights, gauges, and similar items) and each PLCs I/O Module. The Component Calibration Sheet shall include the following as a minimum:
 - 1) Project Name
 - 2) Loop Number
 - 3) Component tag number or I/O module number
 - 4) Manufacturer name
 - 5) Modle number/serial number

- 6) Summary of functional requirements. For example:
 - a) Indicators
 - b) Transmitters/converters, input and output ranges
 - c) Computing elements' functions
 - d) Controllers, action (direct/reverse) and control modes (P&ID)
 - e) Switching elements, unit range, differential (fixed/adjustable), reset (auto/manual)
 - f) PLC I/O modules: input or output
- 7) Calibrations, for example, but not limited to:
 - a) Analog devices: Actual inputs and output at 0, 10, 50, and 100 percent of span, rising and falling
 - b) Discrete Devices: Actual trip points and reset points
 - c) Controllers: Mode settings (P&ID)
 - d) PLC I/O Modules: Actual inputs or outputs of 0, 10, 50, and 100 percent of span, rising and falling.
- 8) Space for comments
- e. Maintain loop status reports, valve adjustment sheets, and component calibration sheets at the project site and make them available to the OWNER at all times.
- f. These inspections and tests, inclusive of the above described forms, will be spot checked by the OWNER.
- g. The ICS shall implement all corrective measures needed and perform re-test on any modified sub-system/component.
- h. The Contractor shall claim and validate a thorough ORT was performed successfully and all resulting corrective action measures taken were performed successfully and re-tested successfully. Upon successful completion of the ORT, the Contractor shall submit letter notification to the OWNER stating that the ORT has been successfully completed. The letter notification shall further state that the ICS is ready to begin the Performance Acceptance Test. Submit all forms upon completion of ORT as required by the OWNER.

G. Performance Acceptance Tests "PAT":

1. Once the ORT has been successfully completed, perform jointly with the OWNER a PAT on the associated PICS to demonstrate that it is operating as required by the Contract Documents. The PAT will employ the OWNER's PLC application software developed for the project.
2. Minimum duration of the PAT shall be a cumulative total of fifty six (56) calendar days. The cumulative total quantity of calendar days shall be consumed in association and in synch with the overall construction sequence for the project. Any Holidays that occur during the PAT shall result in a corresponding number of days being added to the duration of the PAT. The PAT encompasses startup and testing period of the instrumentation and control system for the associated process and mechanical equipment that are controlled and monitored by the instrumentation and control system. The PAT shall be conducted using application software developed by the Engineer. The ICS shall test functions installed and the hard-wired system and the entire associated instrumentation and control system including validating the operation and monitoring and control functions of the all instruments, all control devices, all instrument and control components, control functions, alarm function, monitoring function, calibration ranges, control/alarm setpoint operations, etc. Owner/Engineer shall test software functions. The ICS shall also test the DCS.

3. Demonstrate each required function on a paragraph-by-paragraph, loop-by-loop, and site-by-site basis based upon the operating description used by the OWNER for PLC application software development.
4. Non-loop specific tests shall be the same as previously required except that the entire installed PICS shall be tested using actual process variables and all functions demonstrated.
5. Perform local and manual tests for each loop before proceeding to remote and automatic modes
6. Where possible, verify test results using visual confirmation of process equipment and actual process variable. Unless otherwise directed, exercise and observe devices supplied by Others, as needed to verify correct signals to and from such devices and to confirm overall system functionality. Test verification by means of disconnecting wires or measuring signal levels is acceptable only where direct operation of plant equipment is not possible.
7. Make updated versions of documentation required for PAT available to the OWNER at the project site, both before and during tests.
8. Develop and provide PAT test forms that include the following, at minimum:
 - a. Project name
 - b. Lists the requirements of the loop
 - c. Briefly describes the test
 - d. Cites the expected results and the actual results
 - e. Provides space for checkoff by witnesses.
9. Make one copy of all O&M manuals available to the OWNER at the site both before and during testing.
10. The ICS shall implement all corrective measures needed and perform re-test on any modified system.
11. Prolonged and Excessive Startup and Testing During the PAT (startup and testing period of the instrumentation and control system and the associated process and mechanical equipment that are controlled and monitored by the instrumentation and control system): If parts of a startup and testing of equipment fail and must be redone following the completion of the allotted PAT period and/or startup and testing extends past the PAT period as a result of deficiencies found in the installation of the PICS, and/or startup and testing extends past the PAT period due to prolonged test per piece of equipment resulting from Lack of complete readiness of the ICS and/or the Contractor as well as the associated systems to commence the PAT, and/or not being completely ready to perform the PAT, etc; Any additional time expended by the ICS shall reimburse the Owner for the additional time at the rate of \$150.00 per hour. Additional time is defined as any-time in excess of the total number of allotted Calendar days, based on normal business working hours during the PAT period, for these costs the Engineer will document work hours and other expenses required during the additional time.

5.04 MEASUREMENT AND PAYMENT

- A. No separate measurement or payment for work performed under this Section. Include cost of same in Contract price bid for work of which this is a component part.

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SECTION 17200
INSTRUMENTATION AND CONTROL CABINETS AND ASSOCIATED EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

- A. Furnish, install, and put into satisfactory service the Main Instrumentation/Control Panels, Local Control Panels, Distributed Control System Panels, as specified herein and as shown on the PLANS.
- B. Furnish, install, and put into satisfactory service the modifications to the Owner's existing Main Instrumentation/Control Panels as specified herein and as shown on the Drawings.
- C. The requirements of this Section of the Specifications applies to all of the various types of instrumentation and control cabinets/boxes as specified herein and shown on the PLANS.

1.02 RELATED REQUIREMENTS

- A. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
- B. It is the CONTRACTOR's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR's Work.

1.03 SUBMITTALS

- A. Submit the following in accordance with the Section 01300 and 01730 of the Specifications:
 - 1. Shop drawings and product data. Include paint color selection chart for selection of paint color by OWNER.
 - 2. Operation and maintenance manuals.

1.04 TOOLS AND SPARE PARTS

- A. Furnish the following spare parts in conformance with the specifications :
 - 1. One set (minimum 3) of fuses for each type and size used.
 - 2. One set (minimum 3) of Circuit Breaker Overcurrent Protection Devices for each type and size used.
 - 3. Twenty (20) terminal blocks of each color and type used.
 - 4. Four (4) control relay assemblies of each type specified, complete with all accessories.
 - 5. Four (4) timing relay assemblies of each type specified, complete with all accessories.
 - 6. Four (4) alternator relay assemblies of each type specified, complete with all accessories.

7. Two (2) process variable indicator controller, complete with all accessories
8. Two (2) complete Instrument Loop Current Isolators (I/I converters) for each type specified.
9. 25 percent spare push-buttons, selector switches, indication light assemblies for each type used (minimum of 2 per type).
10. 50 percent of spare lenses and lamps for each type, color and size used (minimum of 4 per type).

PART 2 PRODUCTS

2.01 INSTRUMENT AND CONTROL CABINETS/PANELS/BOXES

A. General:

1. The various instrument and control cabinets/panels shall be constructed to the approximate dimensions and instrument arrangement as shown on the PLANS. The ENGINEER will review alternate arrangements and recommendations.
2. Hinges and doors shall be capable of supporting weight of equipment mounted on doors.
3. Mounting channels and interior panels shall be provided in the cabinets for mounting terminals, relays, etc.
4. The cabinet shall be completely assembled and wired at the factory such that installation can be accomplished by connecting field wiring to terminal strips located in the panel.
5. Furnish and install both isolated and non-isolated ground bars for each cabinet. Furnish and install for each ground bus:
 - a. Required number of terminals for proper wiring in addition to 20 percent spare terminals for future connections
 - b. Isolated Ground Bus Only: 600 volt mounting isolators.
 - c. Certain microprocessor based control equipment will (PLCs, etc.) require the connection of both distorted and undistorted (isolated) ground wires. Provide this wiring as required.

B. Freestanding Cabinets/Panels :

1. Type: Free Standing, modular design, completely enclosed
2. Configuration: Provide Single Bay and Double Bay as required. Use Double-Bay were possible. Each Single Bay section shall have one door, each Double-Bay section shall have two doors, unless specifically shown otherwise on the PLANS.
3. Enclosure Material: Steel
4. Framing Member Thickness: 12 gauge, minimum
5. Door/panel member Thickness: 14 gauge, minimum.

6. Rating: NEMA-12 gasketed
7. Finish: Prime and paint using manufacturer's standard process.
8. Finish color: For Contract Bidding purposes, Foxboro beige with textured finish. The final exterior cabinet components color shall be selected by the OWNER after Contract Bid Award.
9. Interior Panel Finish Color: All interior back and side panels shall be painted white.
10. Additional Requirements for each Door:
 - a. Solid, Gasketed, and Hinged
 - b. 3-point latching mechanism, door latch rods shall have rollers.
 - c. Oil-tight key-locking handle.
 - d. Reinforcing bars for inner device panels
 - e. Data pocket,
 - f. Door stop kit
 - g. Thermostatically controlled exhaust fan complete with filtered louver. Fan rated for 120 volts A. C. Connect as shown on the PLANS. Refer to the PLANS.
 - h. Air intake/exhaust louver. Refer to the PLANS.
 - i. Electrically bonded to the frame using manufacturer's grounding device assembly and #8 AWG green insulated ground wire.
11. Comply with the requirements of the PLANS.
12. Miscellaneous Accessories:
 - a. Provide each section with 7.5 inch high solid plinth base. Include solid base access panel covers.
 - b. Provide 1-1/2 inches high removable heavy duty fiberglass floor grating at the bottom of each section (above the plinth base). The floor grating shall meet OSHA safety standards for personnel traffic. Wiring routed underneath grating shall be neatly laced/arranged.
 - c. Include all back, joining, side, hinged swing-out, etc. panels, slide-out shelves, 19" rack mounting brackets, all associated mounting hardware to facilitate a complete installation and a totally enclosed overall cabinet. Also refer to the PLANS. All panels shall be full height unless specifically shown otherwise on the PLANS.
 - d. Removable lifting eyes
 - e. Panel stabilizers and extra support brackets where conduit connects to the enclosures.
 - f. Cabinet manufacturer's additional hardware and component accessories shall also be provided that will result in a neat, safe, aesthetically pleasing installation.
 - g. Provide overall master nameplate for the cabinet, as hereinafter specified, with the exception that the text height shall be 3/8 inch.
13. The cabinets shall be as manufactured by "HOFFMAN" Model PROLINE Modular Industrial Enclosures complete with specified accessories, or approved equal by "RITTAL"

C. Wall mounted Cabinet/Panel:

1. Type: Wall mounted, completely enclosed

2. Enclosure Material: Type 316 Stainless Steel
3. Enclosure Metal Thickness: 14 gauge, minimum
4. Rating: NEMA 4X gasketed
5. Interior Panel Finish Color: All interior back and side panels shall be painted white.
6. Additional requirements for each Door:
 - a. Gasketed, and Hinged
 - b. Handle.
 - c. Data pocket,
 - d. Door stop kit
 - e. Electrically bonded to the frame using manufacturer's grounding device assembly and #8 AWG green insulated ground wire..
7. Comply with the requirements of the PLANS.
8. Miscellaneous Accessories:
 - a. Internal wall mounting reinforcement.
 - b. Include all back, joining, side, hinged swing-out, etc. panels, slide-out shelves, 19" rack mounting brackets, all associated mounting hardware to facilitate a complete installation and a totally enclosed overall cabinet. Also refer to the PLANS. All panels shall be full height unless specifically shown otherwise on the PLANS.
 - c. Cabinet manufacturer's additional hardware and component accessories shall also be provided that will result in a neat, safe, aesthetically pleasing installation.
 - d. Provide overall master nameplate for the cabinet, as hereinafter specified, with the exception that the text height shall be 3/8 inch.
9. Cabinet/Panel shall be as manufactured by "HOFFMAN" Concept Wall-Mounted Series Industrial Enclosures complete with specified accessories, or approved equal by "RITTAL".

2.02 INSTRUMENT AND CONTROL WIRING

A. General wiring and control Power and alarm wiring:

1. Extra flexible, #14 AWG, tin plated copper conductor 600V insulation, SIS wire manufactured by General Cable Company, The Okonite Company or approved equal. Color coding shall be as follows:

| <u>Wiring Function</u> | <u>Wire Jacket Color</u> |
|---|--------------------------|
| Wiring for 120 volts A.C. control/status/alarm | Red |
| Wiring to actuate electro-mechanical relay coils only | Gray |
| Wiring for 120 volts A.C. power wiring | Gray |
| Wiring for 24 volts D.C. power supply wiring | Blue = Positive |

| <u>Wiring Function</u> | <u>Wire Jacket Color</u> |
|--|---------------------------------|
| | Brown = Negative |
| Wiring for 120 volts A.C. light fixtures and convenience receptacles | Black = Line White = Neutral |
| Wiring to Discrete Input PLC modules | Violet |
| Wiring to Discrete Output PLC modules | Pink |

B. 4-20 Milliamp Signal wiring:

1. Number of Pairs: One
2. Wire Size: #16 AWG
3. Type of Conductors: Stranded copper conductors, twisted
4. Individual Conductor Insulation: PVC
5. Individual Conductor Insulation Color: Positive (+) is Black, Negative (-) is White
6. Drain Wire: Tinned copper
7. Overall Shield: Aluminum-mylar shield.
8. Overall Jacket: PVC
9. Overall Jack Color: Black.
10. Manufacturer: Samuel Moore and Company, Dekoron Division, Cat. No. 1852 or approved equal.

C. Multi-Conductor RTD Temperature Signal Wiring:

1. Number of Triads: One
2. Wire Size: #16 AWG
3. Type of Conductors: Stranded copper conductors, twisted
4. Individual Conductor Insulation: PVC
5. Individual Conductor Insulation Color: Positive (+) is Black, Negative (-) is White, Sense (S) is Red.
6. Drain Wire: Tinned copper

7. Overall Shield: Aluminum-mylar shield.
8. Overall Jacket: PVC
9. Overall Jack Color: Black.
10. Manufacturer: Samuel Moore and Company, Dekoron Division, Cat. No. 1862 or approved equal.

D. RS-232 ModBus Digital Data Communication System Wiring:

1. Number of Pairs: Two
2. Wire Size: #22 AWG
3. Type of Conductors: Tinned stranded copper conductors, twisted
4. Individual Conductor Insulation: 300 volt PVC
5. Individual Conductor Insulation Color: Red, Black, Green, and White.
6. Drain Wire: No. 24 AWG Tinned copper
7. Overall Shield: Aluminum-mylar shield.
8. Overall Jacket: PVC
9. Overall Jacket Color: Chrome.
10. Manufacturer: Belden, Catalog No. 8723, or approved equal.

E. Fiber Optic Cable:

1. Refer to Section 17600 Distributed Control System.

2.03 INSTRUMENT AND CONTROL CABINETS EQUIPMENT

A. Overcurrent Protection

1. General: Individually protect each device as shown on the PLANS. Furnish and install protection using the devices shown on the PLANS and as specified hereinafter.
2. 120 volts AC circuit Protective Devices:
 - a. Ratings: 120 volts A. C., one pole. Size per NEC. Note: Use 20 ampere rating for control panel convenience receptacles.
 - b. Certifications: U. L. Listed.
 - c. Mounting: Din Rail Mountable
 - d. Indications: Visible trip indicator
 - e. Manufacturer: Allen-Bradley Series 1492-SP, Phoenix Contact, or approved equal.
3. 24 volts DC circuit breakers:
 - a. Ratings: 24 volts DC, one pole. Size per NEC.

- b. Certifications: U. L. Listed
- c. Mounting: DIN rail mountable
- d. Indications: Visible trip indicator
- e. Manufacturer: Allen-Bradley Series 1492-GH, Phoenix Contact, or approved equal.

B. Convenience Receptacle:

- 1. Furnish and install where required by the PLANS. Additional receptacle assembly features are as follows:
 - a. Specification grade
 - b. Duplex, 3-wire, polarized grounding type, rated 20 amp, 125 volt, 60 Hertz
 - c. Ivory Color
 - d. Manufacturer: Hubbell No. HBL5362I, Bryant, Pass and Seymour, or approved equal.
 - e. Coverplate: 304 brushed stainless steel, as manufactured by Hubbell, Killark, or approved equal.
 - f. Install in NEMA-1 enclosure inside of the control panel.

C. UPS Receptacle:

- 1. Furnish and install where required by the PLANS. Additional receptacle assembly features are as follows:
 - a. Specification grade
 - b. Simplex grounded twist lock, 3-wire, rated 30 ampere, 120 volt, 60 Hertz,
 - c. Configuration: L5-30R, coordinate final configuration with the UPS requirements.
 - d. Manufacturer: Hubbell HBL2610 or approved equal
 - e. Coverplate: 304 brushed stainless steel, as manufactured by Hubbell, Killark, or approved equal.
 - f. Install in NEMA-1 enclosure inside of the control panel.
 - g. Refer to PLANS for additional requirements.

D. Lighting Fixture:

- 1. Furnish and install where required by the PLANS. Additional light fixture features are as follows:
 - a. Type: Fluorescent
 - b. Voltage: 120 volts A.C
 - c. Length: 2 feet
 - d. Number of Lamps: 2
 - e. Lamp type: Rapid start cool white.
 - f. Integral door switch wired to switch the light based upon door position

E. Pushbuttons, Selector Switches, Pilot Lights

- 1. General Requirements:
 - a. Rating: NEMA 4X corrosion resistant, Heavy Duty
 - b. Size: NEMA Style full size 30-millimeter (30mm),
 - c. Contacts: 10 ampere minimum at 120 volts A.C. Provide number of contacts to satisfy the requirements of the PLANS.
 - d. Legend Plate: Furnish and install per manufacturer's standard with inscription as shown on the PLANS.

- e. Manufacturer: Allen Bradley Bulletin 800H, or approved equal.
2. Additional Requirements for Selector Switch/ Pushbuttons:
 - a. Operator Color: Furnish and install the color as shown on the PLANS, black otherwise.
 - b. Selector Switch Action Type: Maintained action, unless shown otherwise on the PLANS.
 - c. Pushbutton Action Type: Momentary action, unless shown otherwise on the PLANS.
3. Additional Requirements for Pilot Lights:
 - a. Type: Transformer Type Light Emitting Diode (LED),
 - b. Style: Push-to-test
 - c. Lens Color: Furnish and install the colors as shown on the PLANS.
4. Additional requirements for Emergency Stop/Trip Push-Button Stations:
 - a. Action Type: Push-Pull maintained
 - b. Operator Type: Mushroom head
 - c. Operator Color: Red, unless shown otherwise on the PLANS
 - d. Padlock attachment: Furnish and install as manufactured by Allen-Bradley Bulletin Push-Pull Padlocking Attachment Catalog Number 800T-N314, or approved equal.
 - e. Padlock: Furnish and install padlock with 0.25 inch diameter padlock shackle. Coordinate the shackle diameter with the padlock attachment. Furnish and install padlock as manufactured by Master Lock, or approved equal.
- F. Control Relays: Control relays shall be furnished and installed as required by the schematic diagrams. All control relays shall be Type I relays unless specifically noted otherwise on the PLANS or as specified hereinafter.
 1. Type I Control Relays:
 - a. Type: 300 volt "Ice-Cube" type
 - b. Rated: Pilot-Duty C300 rated
 - c. Coil Voltage: 120 volts A.C.
 - d. Contact Rating: 10 ampere at 120 volts A.C.
 - e. Number and Configuration of Contacts: three Form-C Contacts (3PDT)
 - f. Position Indication: Integral LED pilot light
 - g. Manual Operator: Integral to relay
 - h. Mounting: DIN rail mountable socket
 - i. Accessories: Socket, Retaining Clip, Relay Manufacturer's Transient Voltage Suppression Module.
 - j. Manufacturer: "Allen-Bradley" Bulletin 700-HA33A1-1-4, complete with 700-HN203 socket, 700-HSV3 surge suppressor, and 700-HN151 retainer clip, or approved equal.
 - k. The following are additional requirements associated with Type I control relays:
 - 1) Of the maximum of three Form-C type contacts that are available from each Type I Control Relay, one of the Form-C contacts shall be dedicated as "spare" and wired to terminal blocks for future use by the OWNER. Multiple Type I relay coils shall not be connected in parallel in order to develop additional contacts as may be shown on the PLANS. Should the PLANS require greater than two contacts from a control relay, then furnish and install a Type II Control Relay in lieu of a Type I Control Relay.

2. Type II Control Relays:
 - a. Type: 600 volt Heavy-Duty industrial type
 - b. Rated: NEMA rated
 - c. Coil Voltage: 120 volts A.C.
 - d. Contact Rating: 10 ampere at 120 volts A.C.
 - e. Number and Configuration of Contacts: 4 Normally Open and 4 Normally Closed, at minimum. Furnish and install one additional normally open (N.O.) and one additional normally closed (N.C.) contact, over that required by the PLANS. Field configurable type contacts.
 - f. Position Indication: Visual mechanical unlatch-latch indicator
 - g. Mounting:
 - h. Accessories: Relay Manufacturer's Transient Voltage Suppression Module
 - i. Manufacturer: Allen Bradley Bulletin 700-P, or approved equal.

3. Type III Control Relays:
 - a. Type: 300 volt "Ice-Cube" type
 - b. Coil Voltage: 24 volts D.C.
 - c. Contact Rating: 5 ampere at 120 volts A.C.
 - d. Number and Configuration of Contacts: four Form-C Contacts (4PDT)
 - e. Mounting: DIN rail mountable socket
 - f. Accessories: Socket, Retaining Clip
 - g. Miscellaneous: Used only where specifically noted on the DRAWINGS.
 - h. Manufacturer: "Square D", catalog 8501-RSD14M1-V53, complete with relay socket base catalog number 8501-RSD14-NR45 and relay retaining clip 8501-RSD14-NH3, or approved equal.

G. Timing Relays:

1. Type: Solid state, multi-time, and multi-function type relay. Both timing ranges and timing modes shall be field selectable. Each relay shall be capable of the following timing modes: On Delay, Off Delay, One Shot, Repeat Cycle, and Interval
2. Coil Voltage: 120 volts A. C.
3. Contact Rating: 10 amps, continuous, at 120 VAC.
4. Number and Configuration of Contacts: 2 Form C (2PDT)
5. Mounting: DIN rail mountable socket
6. Accessories: Socket, DIN rail mountable
7. Manufacturer: Square D Class 9050 model No. JCK70 complete with Type NR61 Socket, or approved equal.

H. Alternator Relay:

1. Type: Microprocessor based, sequence on, simultaneous off type two load alternator relay. Field selectable switch for alternator function or individual lead selection. LED indicators for stop, lead, and lag discrete inputs as well as load contact outputs.

2. Coil Voltage: 120 volts A. C.
3. Contact Rating: 10 amps, continuous, at 120 VAC.
4. Number and Configuration of Contacts: 2 Form A (SPST)
5. Mounting: DIN rail mountable socket
6. Accessories: Socket, DIN rail mountable
7. Manufacturer: Time-Mark model No. 2611 complete with Model 51X120 Socket, or approved equal

I. Single Input, Dual Output Instrument Loop Current Isolators (I/I Converters)

1. Number and Type of Input Signals: One 4-20mA input signal
2. Number and Type of Output Signals: Two 4-20 mA isolated output signals. Integral load trimmer.
3. Maximum Load: 1200 Ohms per output channel.
4. Power Requirements: External 24 VDC supply as also shown on the PLANS.
5. Accuracy: +/- 0.1% of full span
6. Housing: Corrosion resistant metal
7. Mounting: DIN rail mountable.
8. Noise Protection: Provide RFI /EMI protection such that less than +/- 0.1 % of span error is incurred when tested against a reference signal of 30 volts per meter over the frequency range of 20 to 1000 MHz, inclusive.
9. Transmitter Excitation: Provide with field selectable transmitter excitation option which allows the isolator to supply 24VDC power to a 2-wire instrument connected to the isolator input.
10. Manufacturer: MOORE Industries Model ECT-DIN with TX, or approved equal.

J. Single Input, Single Output Instrument Loop Current Isolators (I/I Converters)

1. Number and Type of Input Signals: One 4-20mA
2. Number and Type of Output Signals: One 4-20mA. Integral load trimmer
3. Maximum Load: 1000 Ohms
4. Power Requirements: External 24 VDC supply as also shown on the PLANS.
5. Accuracy: +/- 0.1% of full span

6. Housing: Corrosion resistant metal
 7. Mounting: DIN rail mountable
 8. Noise Protection: Provide RFI/EMI protection such that less than +/- 0.1 % of span error is incurred when tested against a reference signal of 30 volts per meter over the frequency range of 20 to 1000 MHz, inclusive.
 9. Transmitter Excitation: Provide with field selectable transmitter excitation option which allows the isolator to supply 24VDC power to a 2-wire instrument connected to the isolator input.
 10. Manufacturer: MOORE Industries Model ECT-DIN with TX option, or approved equal
- K. Instrument Control Panels/Cabinets Dual Input Single Output 24VDC Instrument Loop Power Supply:
1. Number of inputs and voltage: Two, 120 volts A.C.
 2. Number of outputs and voltage: Two, 24 volts D.C.
 3. Type: Dual Redundant primary-backup (secondary) arrangement
 4. Topology: Two switching type power supplies connected in parallel via current steering diodes with automatic switchover from the primary to the backup (secondary) power supply unit.
 5. Input Power Regulation: 0.2% from 105 to 130 VAC.
 6. Output Current, per unit: 15 ampere
 7. Output Voltage Adjustment Range: 24 to 28 VDC, field adjustable
 8. Output Voltage Ripple: 0.5% at full load, maximum
 9. Output load regulation: 0.2% maximum from zero to full load.
 10. Output Protection: Integral current limiting and over voltage
 11. Common Alarm Contact Ratings: 5 ampere at 120 volts A.C.
 12. Mounting: Provide rack/wall mounting configuration as shown on the DRAWINGS
 13. Accessories:
 - a. Draw-out handles mounted on the face of the power supply unit.
 - b. Voltage level analog indicator, one per source (primary and redundant).
 - c. Current level analog indicator, one per source (primary and redundant)
 - d. Ventilated metal case.
 14. Manufacturer: Acopian Switching Regulated Redundant Power Package, or approved equal.

L. Thermostat:

1. Type: Heavy Duty line voltage type, suitable for use in controlling heating and cooling circuits. Shall have field adjustable temperature setpoint and also display the measured ambient temperature.
2. Measurement Range:
 - a. Thermostat: 40 to 90 degrees Fahrenheit
 - b. Thermometer: 50 to 90 degrees Fahrenheit
3. Sensing Element: Liquid filled with diaphragm and lever mechanism
4. Thermometer: Bi-metal type
5. Number and Type of Output Contacts: One Single Pole Double Throw (SPDT), snap acting
6. Contact Ratings:
 - a. Heating Contact: 16 ampere at 120 Vac.
 - b. Cooling Contact: 8 ampere at 120 Vac
7. Enclosure: Thermoplastic cover, suitable for vertical or horizontal mounting configuration
8. Accessories:
 - a. Provide temperature adjustment knob
 - b. Provide faceplate with each thermostat with temperature measured in degrees Fahrenheit. Faceplate shall include cutout such that the measured ambient temperature is visible.
 - c. Mount each thermostat in a device enclosure on the enclosure backpanel in accordance with the manufacturer's recommendations.
9. Manufacturer: Johnson Controls Model T26T Series Line Voltage Thermostat, or approved equal

M. Terminal Blocks:

1. General:
 - a. All terminal blocks shall be provided with manufacturer's standard snap-in marker card and holder as manufactured by Allen-Bradley Bulletin No. 1492-SMN81, Phoenix Contact, or approved equal. Provide manufacturer's standard typed adhesive terminal block tag for each terminal block.
 - b. Provide manufacturer's standard insulating jumpers, DIN rail, barriers, end anchors, etc., and all related mounting hardware as required for a complete and functional installation. Coordinate models of terminal block accessories such as end anchors, jumpers, DIN rail, etc., with the terminal blocks as specified hereinafter for a complete and functional installation.
2. Type I Terminal Blocks:
 - a. Rating: 600 volts A.C./D.C., 55 ampere
 - b. Type: Single Layer
 - c. Wire Range: No. 22 through No. 8 AWG

- d. Material: Nylon or polypropylene
 - e. Quantity per Foot: 37
 - f. Color: As specified hereinafter.
 - g. Manufacturer: Allen-Bradley Bulletin 1492-HM3, Phoenix Contact, or approved equal.
3. Type II Terminal Blocks:
- a. Rating: 600 volts A.C./D.C., 24 ampere
 - b. Type: Two Layer
 - c. Wire Range: No. 30 through No. 12 AWG
 - d. Material: Nylon or polypropylene
 - e. Quantity per Foot: 50
 - f. Color: As specified hereinafter.
 - g. Manufacturer: Allen-Bradley Bulletin 1492-HM2, Phoenix Contact, or approved equal.
4. Type III Terminal Blocks:
- a. Rating: 300 volts A.C./D.C., 12 ampere
 - b. Type: Single Layer, fused terminal blocks
 - c. Wire Range: No. 30 through No. 12 AWG
 - d. Material: Nylon or polypropylene
 - e. Quantity per Foot: 33
 - f. Fuse: Bussman ¼ inch x 1-1/4 inch.
 - g. Miscellaneous: Provide with LED blown fuse indicator
 - h. Manufacturer: Allen-Bradley Bulletin 1492-H5, Phoenix Contact, or approved equal.
5. Terminal Block Colors: Provide terminal blocks with the colors as follows:

| <u>Terminal Block Function</u> | <u>Terminal Block Color</u> |
|---|-----------------------------|
| Terminal Blocks for 120 volts A.C. control/status/alarm/ PLC monitoring | Red |
| Terminal Blocks for 120 volts A.C. power wiring | Black |
| Terminal Blocks for Ground wiring | Green |
| Terminal Blocks for 24 volts D.C. wiring | White |

- N. Flexible spiral wrapping: Size as required. Provide as manufactured by Electrovert Spiraband, or approved equal.
- O. Plastic Wireway: Size as required. Also refer to the PLANS. Provide white color unless specified otherwise. Provide as manufactured by Panduit, or approved equal.
- P. Manual Speed Potentiometer: Variable Resistance (potentiometer) shall be a single turn potentiometer as required by the PLANS. Each Potentiometer shall have a resistance per the requirements of the VFD manufacturer. The color of the Potentiometer operators shall be

BLACK unless otherwise noted on the PLANS. The Manual Speed Potentiometer shall be as manufactured by ETI Systems, Model SP22E-SB-5K SEALED BODY POTENTIOMETER.

Q. Multi-Outlet Power Strip: Furnish and install where shown on the PLANS.

1. Shelf Mounted: Provide white color unless specified otherwise. Multi-Outlet Power Strip shall have six 15 ampere, 120 volt NEMA 5-15R receptacles, U. L. Listed, main circuit breaker and integral on/off switch and indicator light and integral 4 foot power cord. Furnish and install as manufactured by Kensington Model 50688 or approved equal.

R. Process Variable Transmitter Indicator Controller:

1. Type: Microprocessor based digital transmitter indicating controller capable of receiving an input analog signal, actuating alarm contacts based upon field configurable setpoints, displaying the input signal, and re-transmitting the input signal via an isolated analog output signal transmitter.
2. Display: 6 digit, 0.6 inch high Light Emitting Diode (LED), red in color
3. Input Signal:
 - a. 4-20mA at 24VDC
 - b. Signal proportional to the process variable measured
 - c. Input Impedance: 100 ohms maximum
 - d. Accuracy: Plus or minus 0.03 percent of calibrated span plus or minus one count
4. Units: Calibrated in engineering units (applicable to the specific system and measured variable) in order to indicate and control the process variable in the same units (i.e., GPM/MGD for Flow, Inches/Feet for Level, PSI for Pressure, °F/°C for Temperature, etc.).
5. Conversion Rate: 5 conversions per second
6. Programming Method: Field programmable using buttons on the face of the controller.
7. Discrete Outputs: Four field programmable Form C dry output relay contacts each rated for 3 ampere at 120 Vac. Relays shall be capable of being assigned to any combination of high/low set points. Each set point shall have user selectable deadband of 0 to 100 percent of the input signal range. Relays shall be capable of being field programmed for latching, non-latching, and fail-safe operation. The Contractor shall field program the relays for fail-safe operation.
8. Output Signal:
 - a. 4-20 mADC at 24VDC
 - b. Signal proportional to the input signal
 - c. Output signal shall be isolated from the input signal
 - d. Accuracy: Plus or minus 0.1 percent of calibrated span plus or minus 0.004 maDC.
9. Enclosure: 1/8 DIN high impact plastic enclosure with Nema 12 rated front panel at minimum.
10. Operating Temperature: -40 to +65 degrees Celsius

11. Power: Single phase, 120 Vac input, 60 Hz
12. Manufacturer: Precision Digital Model PD6000, or approved equal.

2.04 UNINTERRUPTIBLE POWER SUPPLY, PROGRAMMABLE LOGIC CONTROLLERS
“PLCS”, AND ASSOCIATED EQUIPMENT

- A. Refer to Specifications Section 17600, “Distributed Control System” of the Specifications.

2.05 IDENTIFICATION

- A. Instrument and Control Devices Identification

1. General:

- a. The device designations shall agree with those shown on the PLANS.
- b. Each device shall be provided with permanent type identifying nameplate.
- c. Nameplates:
 - 1) Type: 3-ply, 1/8” thick, rigid thermoset phenolic resin laminated cellulose paper base engraving stock per ASTM D-709, Type I. Nameplates shall be ASTM Grade ES-1, ES-2, or ES-3 as applicable for the face and lettering colors specified hereinafter. Flexible or acrylic tags will not be accepted.
 - 2) Color: White-Black-White, unless shown otherwise on the PLANS.
 - 3) Lettering: 1/4 inch height minimum unless shown otherwise on the PLANS, engraved through the face layer to the melamine middle layer.
 - 4) Accessories: Provide holes for mechanical fastening.

2. Devices located on the face of, on the back, or inside of instrument control cabinets/panels:

- a. Devices which penetrate the door shall be provided with two nameplates, one located on face of the door and one located on the rear of the door.
- b. Nameplates located on the panels/cabinets face shall be secured with two Type 316-Stainless Steel screws.

3. Field mounted control and instrument devices:

- a. Securely hang nameplates from each instrument/control device by a flexible stainless steel snap-on type hanger/key-chain cord (neatly drill a hole through the top of the identification nameplate for this purpose).

- B. Wire Tag:

1. Rating: Flame-Retardant,
2. Style: Heavy-Duty Industrial Grade
3. Type: Heat Shrinkable type.
4. Character Height: 1/8 inch.
5. Maximum Length: 2 inches.
6. Text Type: Typed with indelible marking process. Handwritten shall not be accepted.

7. Color: Yellow. Exception: Use White for 120 volts A.C. power circuits to instrument/devices, and branch circuit lighting and convenience receptacle circuits.
8. Manufacturer: "Raychem type Heavy-Duty Industrial Grade ShrinkMark Heat-Shrinkable Marking Sleeves", or approved equal. Utilize "Raychem" Portable-Marking-System" complete with wire tag cartridges, or approved equal.

2.06 MISCELLANEOUS

A. Corrosion Resistant and Moisture Repelling Electrical Coating/Spray:

1. Color: Clear. Coordinate spray color with the Owner. Furnish and install the color requested by the Owner at No Additional Cost to the Owner.
2. Type: Corrosion resistant and moisture repellent fast drying spray coating sealant
3. Manufacturer: "3M" 1601 Clear-Color Fast Drying Sealer and Insulator, or approved equal.

PART 3 EXECUTION

3.01 STORAGE

- A. Storage: Refer to Section 17100.

3.02 PANEL ASSEMBLY

- A. All panel assembly, internal wiring, device installation, tagging, etc. shall be accomplished by the ICS prior to shipment. All wiring shall be connected as shown on PLANS and all systems shall be thoroughly checked out prior to shipment of the panel to the site. Additional requirements are as described below.
- B. Termination and Routing of Wiring:
1. Prior to being connected to any instrument or switch, all incoming wiring shall be terminated to terminal blocks located on an interior panel. Although multiple types of terminal blocks are specified, not all types may be used for this project. Terminal block application shall be limited as follows:
 - a. Type I Terminal Blocks: All proposed control panels/cabinets specified herein.
 - b. Type II Terminal Blocks: Used at the discretion of packaged control system manufacturer as defined in Section 13390 for process/mechanical equipment with packaged control systems.
 - c. Type III Terminal Blocks: Used at the discretion of packaged control system manufacturer as defined in Section 13390 for process/mechanical equipment with packaged control systems.
 2. Each pumping unit shall have its individual control wiring terminal block/strip segregated and isolated from terminal block/strip of any other pumping unit.

3. Each PLC shall have dedicated terminal strips for each analog input, analog output, discrete input, and discrete output module, with each point from each module wired out and terminated to terminal blocks i.e., all input/output module points, where shown active or as spare, shall be wired out and terminated to terminal blocks. Spare points shall be treated the same as any other active point and shall follow the same format described under wiring/terminal block tagging scheme/strategy/method. Also refer to and comply with the requirements of the PLANS.
4. Provide separate terminal blocks for power wiring, from control/discrete signal wiring, and from analog/instrument wiring. Additionally, segregate and isolate analog/instrument terminal strips from control/discrete signal wiring terminal strips from power wiring terminal strips.
5. Terminate shield wire of each shielded cable to a terminal point (block) on the terminal strip (i.e., treat as current carrying conductor), with each shield terminated to a dedicated terminal block. Extend No. 14 AWG insulated green ground wire from each shielded cable shield termination terminal point to the isolated main ground bar of the cabinet (shield/drain wire ground).
6. Wire spare contacts of each device (i.e., control relays, timing relays, selector switches, indicating/controlling instruments/devices, etc.) to terminal blocks for future use by the OWNER.
7. Tag each terminal block. All tags must be typed and neatly attached to the marking surface.
8. Tag each terminal strip/string of terminal blocks with nameplates as previously specified.
9. Terminal blocks shall have the colors previously specified according to the function of the terminal block.
10. Utilize manufacturer's standard terminal block insulated side jumpers for making connections between adjacent terminal blocks.
11. Route all wiring from a device (instrument, relay contact, push button, etc.) through the terminal block to the other device (instrument, relay contact, push button, etc.) rather than directly from one device to the other.
12. All wiring shall be neatly bundled, laced together and routed as required throughout the cabinet. Enclose wiring routed against the back panel in plastic wireways where possible. Otherwise, group where possible and wrap with flexible wire wrapping or waxed twine. Wiring routed on doors shall be routed such that the door can be fully opened without stressing the wiring.
13. Wire entering the cabinets shall enter through the floor, the side and/or the top of the cabinets via conduits with bushings or hubs.
14. Also refer to and comply with the requirements of the PLANS.

C. Wire Tagging

1. Tag each wire at each end.
2. Tag each wire in multi-conductor cable in addition to the overall cable.
3. Heat shrink all wire tags.
4. Wire Tag Content:
 - a. Wiring of each equipment (such as Distribution Service Pump, Pump Discharge Control Valve, etc.) within the facility must be tagged different from any other equipment
 - b. Terminal block terminal designation must be included in the wire tag.
 - c. To represent all of the text to be shown, multiple wire tags may be needed at each end of the wire. Provide additional tags as necessary at no additional cost to the OWNER.
 - d. Provide per Section 16200 "Wiring (600 volt and Below), subsection 3.03 "Wire Tagging Methodology".

D. Special and additional installation requirements associated with fiber optic communication system:

1. The fiber cables entering each cabinet shall be coiled, allowing at least 8-feet of additional cable. The coiled fiber shall be positioned vertically. The fiber bend radius upon entry and coiling must not be less than the minimum required for the cable.
2. The fiber optic cable shall be enclosed in a plastic, flex material. This flex material shall surround the cable for all routing of the cable.

E. After all wiring connections have been made, the Contractor shall apply the Corrosion Resistant and Moisture Repelling Electrical Coating/Spray to all wiring connections. Coordinate application with the Owner. The extent of spray application is further clarified as follows:

1. Spray shall be applied for all terminations of the following types of connections at a minimum:
 - a. termination points, terminals, terminal blocks, ground bar, neutral bar/bus,
 - b. lugs of circuit breakers, buses, doors, etc.
 - c. exposed/stripped ends of each conductor, etc.
 - d. bolt-on connections, split-bolt connections, ring lugs, etc.
 - e. compression connectors, connector blocks, etc.
 - f. all other connection types not listed above
2. Spray shall be applied for all terminations at the following types of equipment at a minimum:
 - a. Local and main control panels, field instruments, junction boxes, field control stations, control relays, signal isolators, selector switches, pushbuttons, etc.,
 - b. Panelboards, transformers, motor control centers, manual motor starters, contactors, light switches, light fixtures, etc.
 - c. Motor termination enclosures, valve actuators, cathodic protection system, package control panels of process equipment, etc.
 - d. Security system devices, cameras, roadway gate operators, etc.

- e. Convenience receptacles, scada receptacles, etc.
- f. All other types of equipment not listed above.

3.03 FIELD INSTALLATION

- A. Install the panels in the locations shown on the PLANS. Also refer to the installation details shown on the PLANS.
- B. All wiring shall be connected as shown on PLANS and all systems shall be thoroughly checked out.
- C. Install all equipment in accordance with the drawings and instructions furnished by the manufacturer.
- D. Inspect each new instrument, control component, etc., before installation. Replace deficient items.
- E. Touch-up and restore damaged surfaces to factory finish to match existing.

3.04 INSTALLATION REPORT

- A. After installation, the manufacturer's representatives shall inspect the installation and prepare a report or reports to include the following:
 - 1. A list of all deficiencies found.
 - 2. Recommend corrective action for all deficiencies.
 - 3. Certification that the item or system is properly installed, except as noted.

3.05 FIELD CALIBRATION AND TESTING

- A. Calibrate instruments and prepare calibration reports. All calibration shall be performed by factory-trained technical personnel. Calibration shall be witnessed by OWNER.
- B. The complete system shall be tested by an experienced factory-trained technical person. All system tests shall be witnessed by OWNER.
- C. Perform the following tests using simulated inputs:
 - 1. Check the overall system and each subsystem to see that they function as specified based on simulated inputs at each sensor and at each set of field contacts monitored. This check shall include the testing of all automatic functions, sounding of alarms, shutdowns, etc.
 - 2. Check the overall accuracy of each new and modified instrument loop to ensure that it is within acceptable tolerance.
- D. If defects are found under simulated conditions, make corrections and retest.
- E. After start-up, test the complete system under actual conditions to determine that all specified functions can be performed.

- F. After completion of testing, submit a System Test Report. This report shall include:
 - 1. Certification that the system is operating correctly and within tolerances.
 - 2. Listing of calculated tolerances for each new and modified instrument loop.

3.06 OPERATION AND MAINTENANCE TRAINING

- A. Start-up Training: Provide required instruction to the OWNER's personnel during start-up period.
- B. Special Training School: Provide services of a factory-trained instructor or instructors for a period of not less than two (2) working days for the purpose of instructing the OWNER's personnel in the correct operating and maintenance procedures for all the instrument and hard-wired control system components and the entire Instrumentation and Control System, and Communications System including the various instrument and control system cabinets/panels installed in this project. This is in addition to the training requirements defined in Section 17600 of the Specifications. The date of this school shall be scheduled with the OWNER, but will be after the entire instrument and control systems is in operation. Also, refer to the additional training requirements defined in Section 17600 of the Specifications.

3.07 MEASUREMENT AND PAYMENT

- A. No separate measurement or payment for work performed under this Section. Include cost of same in Contract price bid for work of which this is a component part.

END OF SECTION

SECTION 17380
FIELD INSTRUMENTATION AND SENSING DEVICES

PART 1 GENERAL

1.01 SUMMARY

- A. The work performed under this Section consists of furnishing, installing, calibrating and placing into satisfactory service the following field mounted devices as shown on the PLANS:
1. Intelligent Pressure Measuring Indicating Transmitter
 2. Intelligent Temperature Indicating Transmitter
 3. Ultrasonic Level Element and Indicating Transmitter
 4. Submersible Level Transducer and Indicating Transmitter
 5. Electrical Conductivity Actuated Level Switch
 6. Mechanical Level Switches
 7. Pressure Switches
 8. Thermal Dispersion Flow Switch
 9. Tubing, Hand Valves and Fittings
- B. The subsequent document entitled "Section 17380 Appendix A – South Austin Regional WWTP Gravity Thickener Improvements Instrument List" is hereto made part of this section and includes a listing of the proposed instruments.
1. The minimum and maximum range in the Instrument List provides the required calibrated span of each instrument.
 2. Where the instrument functions as a switch, the minimum/maximum value indicates the low/high switch setting. Where the value is noted as "N/A", the low or high setting is not applicable for the instrument.
 3. The Instrument List is not inclusive of all instruments required by this contract. Refer to Part 1 of this section for quantities of spare parts and instruments in addition to those listed in the Instrument List. Refer to the Plans and other specification sections for additional instruments required by these contract documents.
 4. Where a PLAN sheet number is shown in the list, and a "/" is listed, the number shown prior the "/" refer to a specific detail number on that sheet.
 5. The list includes PLAN drawing numbers applicable to the specific instrument installation and wiring. This list of drawing numbers is not complete. Refer to the PLANS for additional instances and requirements for these instruments.

6. Where items in the list are left blank and/or not entered, CONTRACTOR shall note these items on the data submittals and request input from the Process Mechanical ENGINEER for clarification during submittal review.

C. Instrument Type Code:

1. An Instrument Type Code identifies each instrument and consists of an alphanumerical character followed by three numeral characters.
 - a. Example Instrument Type Code: "A123".
2. The Type Code listed in the Instrument List serves as a means to reference each instrument in the Instrument List to the specifications.

1.02 RELATED REQUIREMENTS

- A. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
- B. It is the CONTRACTOR's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR's Work.

1.03 SUBMITTALS

- A. Submit the following in accordance with the Section 01300 and 01730 of the Specifications and in accordance to Section 17100 of the Specifications:
 1. Shop Drawings and product data.
 2. Submit wiring schematics for all equipment.
 3. Test Reports: Completed and certified factory and field calibration data sheets for instruments and devices that require set-up and calibration.
 - a. Include factory calibration for each instrument with stated accuracy.
 4. Operation and maintenance manuals.
 - a. Include all completed and certified test reports in manuals.
- B. Submit detailed listing of training class curriculum including, as a minimum, the following at least four (4) months prior to class:
 1. Specific topics for each instrument, including but not limited to, general trouble-shooting, calibration, wiring, and general set-up/configuration.
 2. Anticipated duration of class for each instrument type.
 3. Names of instructor(s) for each specific instrument.
 4. Refer to instrument by Instrument Type Code as listed in this specification section where applicable.

1.04 QUALITY ASSURANCE

- A. Standardization: All equipment of the same Instrument Type Code to be the product of a single manufacturer.
- B. Examine the complete set of Contact Documents and verify that the instruments are compatible with the installed conditions including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
 - 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
- C. Notify the ENGINEER if any installation condition does not meet the instrument manufacturer's recommendations or specifications.
- D. Material Compatibility:
 - 1. Material selections of instrument components noted in this section provide a basis for the minimum material compatibility requirements.
 - 2. Instrument component material selections shall be subject to additional restrictions and compliance with recommendations of instrument manufacturers for the intended service.
 - 3. Provide instrument component materials in compliance with specific process fluid temperature, pressure, chemical compatibility, and other process fluid parameters.

1.05 TOOLS AND SPARE PARTS

- A. Furnish the following spare Field Instrumentation and Sensing Devices in conformance with the Specifications:
 - 1. One set of complete Type P133 Intelligent Pressure Measuring Indicator/Transmitter, furnished complete with accessories specified.
 - 2. One set of complete Type P104 Intelligent Pressure Measuring Indicator/Transmitter, furnished complete with accessories specified.
 - 3. One set of complete Type L102 Ultrasonic Level Element and Indicating and Transmitter, furnished complete with accessories specified.
 - 4. Two sets of complete Type F405 Thermal Dispersion Flow Switch, furnished complete with accessories specified.
 - 5. One set of complete Type L302 Electrical Conductivity Actuated Level Switch, furnished complete with accessories specified.

6. One set of complete Type L207 Submersible Level Transducer and Indicating Transmitter, furnished complete with accessories specified.
 7. Two sets of L410 Mechanical Level Switches, furnished complete with accessories specified.
 8. One set of complete Type L415 Mechanical Level Switch, furnished complete with accessories specified.
 9. Five sets of Instrument Tubing Hand Valves.
 10. Five sets of Instrument Tubing Elbow Fittings and Tee Fittings.
- B. Cable lengths and capillary lengths of spare instruments/equipment shall match that of installed respective type of instrument/equipment. Where lengths of same type of installed instruments are not the same, respective spare instrument shall be provided with cable length and/or capillary tubing length matching longest cable and/or capillary tubing length of respective set of instruments installed. Provide all accessories, kits and mounting hardware as specified for each spare instrument.
- C. Spare instrument shall be configured to match one of the installed instruments.
1. Where multiple instruments of the same type are installed:
 2. Configuration of spare instrument shall be as directed by Engineer during construction.
 3. Request input from Engineer during submittal process as to which configuration is desired for the spare instrument.

1.06 ACCEPTABLE MANUFACTURERS

- A. Each type of Instrument shall be manufactured by a single Instrument manufacturer and additional requirements as follows:
1. All pressure indicating transmitters shall be manufactured by a single Instrument manufacturer.
 2. All temperature indicating transmitters shall be manufactured by a single Instrument manufacturer.
 3. All level indicating transmitters shall be manufactured by a single Instrument manufacturer.
- B. Refer to the individual instrument subsection in PART 2 - PRODUCTS, below.

PART 2 PRODUCTS

2.01 INTELLIGENT PRESSURE MEASURING INDICATING TRANSMITTER

A. P100 Series General Requirements:

1. The Pressure Indicator/Transmitter shall have the following features:
 - a. Signal: Two-wire 4-20mA_{dc} (loop powered) proportional and linear to Pressure with HART communication protocol.
 - b. Accuracy: 0.2 percent of span
 - c. Repeatability: 0.2 percent of span
 - d. Ambient Temperature Range: -40 degrees Fahrenheit to + 185 degrees Fahrenheit
 - e. Process Temperature Range: -50 degrees Fahrenheit to +250 degrees Fahrenheit
 - f. DC Loop Supply Voltage Range: 12 to 42 VDC
 - g. Signal Output Load Range: 200 to 1,450 ohms.
 - h. Transmitter Total Error: 0.1 percent (RMS), at a reference range of 0 to 100 PSI inclusive of all effects
 - i. Measurement Range: Select the measurement range offered by the instrument manufacturer for the specified model series that offers the greatest available accuracy for the required span of measurement as listed in Appendix A – Instrument List.
 - j. Indicator Requirements:
 - 1) Type: Digital LCD integral to transmitter
 - 2) Calibration: Field configurable, as desired by the user
 - a) Span: As listed in Appendix A – Instrument List.
 - b) Measurement Unit: As listed in Appendix A – Instrument List.
 - k. Power: Loop powered (4-20mA at 24 VDC) with 1/2" NPT conduit connection.
 - l. Sensor Wetted Parts Material: Type 316L Stainless Steel
 - m. Sensor traditional bottom works, process covers and process connectors: Type 316-Stainless Steel with supply vent screw in side of each process cover with traditional bottom works (not coplanar) configuration.
 - n. Sensor Fill Fluid: Silicone oil.
 - o. Process Connection: 1/2 inch NPT.
 - p. Transmitter Housing: Epoxy coated aluminum, explosion proof NEMA-4X.
 - q. Hardware: Type 316 Stainless Steel.
 - r. Local Operation: The Indicator/Transmitter shall be equipped with operators on the face of the unit adjacent to the local indicator for configuration and calibration functions. The face of the unit is the side of the unit that includes the local indicator.
2. Process Pipe Pressure Tap Valves: Refer to PLANS for valving on process piping pressure tap, in addition to any instrument valves specified in this section.
3. Pressure Seal Requirements: For instrument Type Codes with pressure seal.
 - a. Temperature Error: Less than 0.3% instrument error based on the pressure span when the volume of fill fluid is subject to a 30 degree Fahrenheit change in temperature.
 - b. Pressure Ratings: Rated for same pressure as the process piping system that it serves and shall be continuous-duty design rated to prevent loss of process fluid if pressure instrument is removed or fails.
 - c. Fill Fluid: Inert fill fluid shall be used where the process fluid is a strong oxidizing agent, including but not limited to, oxygen, chlorine, fluorine, nitric acid, and hydrogen peroxide.

- d. **Material Compatibility:** For process fluids not noted in this Specification Section, coordinate with the Diaphragm Seal Factory for recommended material compatibility and submit to ENGINEER for review.
 4. **Mounting:** Manufacturer's Type 316 Stainless Steel traditional style mounting bracket for mounting transmitter and valve block manifold on 2-inch pipe stand, with manifold installed between transmitter and bracket. Provide stainless steel flange to mount vertical pipe stand to floor. Also refer to the PLANS.
 5. **The Intelligent Pressure Measuring Indicators/Transmitters** shall be as manufactured by Foxboro Series IGP20-A (Intelligent Gauge Pressure Transmitters) with specified accessories, or Engineer approved equal.
- B. P104: Intelligent Pressure Measuring Indicating Transmitter with Block Valve and Tubing
1. **General Requirements for P100 Series Intelligent Pressure Measuring Indicating Transmitters** apply to this type of instrument.
 2. **Instrument Valves:** Provide factory furnished, 2-way Valve Block Manifold; constructed of 316 Stainless Steel wetted and non-wetted parts, to accept 1/2 inch NPT; with gaskets and 316 Stainless Steel bolts; Tyco Flow Control Anderson Greenwood Model M4TP-VIS4 or Engineer approved equal. Refer to PLANS for additional valving on process piping pressure tap.
 3. **Instrument Tubing:** Provide instrument tubing to process line connections at valve block process port. Refer to tubing and fittings requirements in this Specification Section. Refer to PLANS for additional requirements.
- C. P133: Intelligent Pressure Measuring Indicating Transmitter with Remote Threaded Diaphragm Seal
1. **General Requirements for P100 Series Intelligent Pressure Measuring Indicating Transmitters** apply to this type of instrument.
 2. **Diaphragm Pressure Seal and Capillary Tubing:** Provide factory furnished, factory assembled pressure transmitter assembly including capillary tubing and diaphragm seal, with fill fluid factory filled and sealed, PI Components T4 Series, or Engineer approved equal. Provide seal system to comply with the following requirements:
 - a. **Type:** Remote mount, One Seal System
 - b. **Size:** 4 inch diameter diaphragm
 - c. **Process Connector:** 1" threaded NPT, internal threads
 - d. **Pressure Rating:** Housing, diaphragm and bolt system rated for 750 psig minimum process fluid pressure
 - e. **Lower Housing Material (Process Wetted):** 316 Stainless Steel
 - f. **Diaphragm Material:** 316L Stainless Steel
 - g. **Upper Housing Material:** 316L Stainless Steel
 - h. **Gasket:** Teflon (PTFE)
 - i. **Instrument Connection:** 1/4" NPT Capillary welded to transmitter.
 - j. **Flushing Connector:** Two (2) 1/2" NPT on each side of lower housing, with plug having same material as lower housing.
 - k. **Bolting:** Type 316 Stainless Steel

- l. Fill Fluid: DC200, 10 cSt Silicone
- m. Capillary Internal Diameter: 0.040 inches
- n. Capillary Type: Type 316L Stainless Steel Flexible Armor
- o. Capillary Length: Size length of tubing to suit installed conditions and to allow a minimum of 3 feet and a maximum of 8 feet of slack.

2.02 INTELLIGENT TEMPERATURE MEASURING INDICATORS/TRANSMITTERS

A. T100 Series General Requirements:

1. The Temperature Indicators/Transmitters shall be of the intelligent type and shall measure and convert the temperature from a temperature sensor element to a 4-20 mAdc electrical and digital output that is Linear with the actual temperature of fluid being measured.
2. The Temperature Indicator/Transmitters shall have the following features:
 - a. Communication Signal: Two-wire 4-20 mAdc (loop powered) and HART digital output (software selectable) proportional and Linear with the actual measured temperature of the process variable.
 - b. Temperature Span: 140 degrees F to 1200 degrees F.
 - c. Accuracy: 0.02 percent of calibrated span of the 4-20mA analog output
 - d. Stability: 0.25 percent of calibrated span or 0.5 degrees Fahrenheit, whichever is greater, for five years
 - e. Operating Temperature: -40 degrees Fahrenheit to +185 degrees Fahrenheit
 - f. DC Loop Supply Voltage: 12 to 42 VDC
 - g. Output Load: 0 to 1,250 Ω (Ohms)
 - h. Conduit Connection: 1/2 inch NPT
 - i. Digital Accuracy: +/- 0.18 degrees Fahrenheit
 - j. Hardware: All bolts, process connections, and hardware shall be Type 316 Stainless Steel.
 - k. Housing:
 - 1) Enclosure of the Indicator/Transmitter shall be Low-copper aluminum.
 - 2) Rated for use in Class-I, Division 1, Groups C and D hazardous areas (as classified by NFPA 70 National Electrical Code).
 - a) Local Indication:
 - (1) Local indicator (integral to Indicators/Transmitters) which is calibrated in "degrees F" and to the range of the transmitter (or to the range of the process variable range selected by the Owner).
 - (2) The indicator shall be of the digital type with liquid crystal display (LCD), driven by the loop power (4-20mA at 24 VDC), and have an accuracy within 0.075 percent full scale.
 - b) Local Operators:
 - (1) The Indicator/Transmitters shall be equipped with operators on the face of the unit for configuration and calibration functions.
 - (2) External and/or internal source/devices (such as handheld programmer and/or Portable Computer) shall not be required in order to configure, program, and calibrate the Indicators/Transmitters.
3. The Temperature Sensor Element for each Indicator/Transmitter shall have the following features:
 - a. General: 4-wire, single element, 100 Ω (Ohms) Resistance Thermometer Detector (RTD), Platinum, in accordance with IEC 751 Class A.

- b. Enclosure: Enclosed in a Type 316 Stainless Steel sheath.
 - c. Sensor Lead Wire Termination: For application where sensor is not mounted integral to the transmitter, provide sensor with aluminum connection head and cover with 1/2 inch NPT conduit connection.
 - d. Sensor Assembly: Type 316 Stainless Steel spring-loaded style sensor assembly having 1/2 inch NPT.
 - e. Temperature Range: -328 to +932 degrees Fahrenheit
 - f. Length: Provide length of element required to span entire length of thermowell and required sensor connections.
4. The Sensor Element Thermowell shall have the following features:
 - a. General: Each Sensor Element shall be provided with a Type 316 Stainless Steel Full Length thermowell (protecting tube).
 - b. Shank Style: Tapered shank geometry, with smaller diameter at terminal tip of thermowell.
 - c. Hardware: The thermal well assembly shall be furnished complete with external threads, explosion proof union, and required accessories/hardware for installation onto process mechanical piping, duct/chamber and/or raceways shown on PLANS. All mounting accessories/hardware shall be constructed of Type 316 Stainless Steel.
 - 1) Exception: Union is not required when thermowell is mounted only to transmitter and not mounted to process mechanical piping, duct/chamber, raceways or other fixed element.
 5. The Intelligent Temperature Measuring Indicators/Transmitters along with the associated Temperature Sensing Element and System shall be as manufactured by Rosemount Series 644 Intelligent Temperature Transmitters with Series 78 Sensor Element, Series 91 Thermowell and specified manufacturer furnished accessories, or Engineer approved equal.
- B. T103: Intelligent Temperature Measuring Indicators/Transmitters with Integral Temperature Element for Ambient Temperature Measurement
1. General Requirements for T100 Series Intelligent Temperature Measuring Indicators/Transmitters apply to this type of instrument.
 2. The Temperature Indicator/Transmitters shall have the following features:
 - a. Mounting: Integral to sensor.
 3. The Sensor Element Thermowell shall have the following features:
 - a. Length: 6 inches.
 - b. Sensor Assembly Connection: Mounted directly to Indicating Transmitter with required 316 Stainless Steel connector fittings.

2.03 ULTRASONIC LEVEL ELEMENT AND INDICATING TRANSMITTER

A. L100 Series General Requirements:

1. The Transmitter/Controller shall have the following features:
 - a. Operation and Performance:
 - 1) Solid-state microprocessor controlled digital circuitry.
 - 2) Operating Temperature: -5 to +122 degrees Fahrenheit.

- 3) Temperature Compensation: Equipped with air temperature compensation corrosion resistant probe. The temperature probe shall be a separate device from the ultrasonic transducer.
 - 4) Range/Span Adjustment Resolution: 0.012 inches for operating span of 1 to 50 feet and direct reading zero adjustments.
 - 5) Minimum Span: 0 to 4 inches.
 - 6) Maximum Span: 0 to 50 feet.
 - 7) Accuracy: +/- 0.25 percent of span.
 - 8) Blanking: adjustable distance from 16-inches to maximum span limits
 - a) Enclosure: NEMA-4X, wall mount, corrosion resistant, watertight, and rated/suitable for use in NEC Class-1 Division-2 area installation.
 - b) Interface and Display:
 - (1) LCD indicator reading; level in engineering units.
 - (2) Keypad for programming the system and accessing diagnostics.
 - c) Signals: 4-20mA DC output proportional to level measurement and all of the full-scale volume or head range.
 - d) Auxiliary Relays:
 - (1) Furnished with six (6) auxiliary relays for remote alarm/process equipment control.
 - (i) Four relays shall each have a Form A normally open dry contact, rated 5 amps at 120VAC.
 - (ii) Two relays shall have single-pole-double-throw (SPDT) dry contacts, rated 5 amps at 120VAC.
 - (2) In the case of momentary signal loss, relays shall maintain their last state.
- b. Power:
 - a) Main Supply: 120VAC, 60Hz power source.
 - b) Program Memory: Non-volatile for a period of six (6) months via a Ni-Cad battery pack (furnished with the system); charged continuously.
2. Temperature Transducer and Signal Cable shall have the following features:
 - a. Enclosure: Totally encapsulated corrosion resistant ETFE.
 - b. Mounting: Refer to the PLANS for mounting requirements of the temperature transducer.
 - c. Connections: 3/4-inch conduit hub for conduit/wire termination.
 - d. Cable: Length: As required per PLANS for connection to the transmitter/controller without any cable splices. Transmitter may be located up to 1,000 feet from the transducer.
 3. Each Ultrasonic Level Indicator/Transmitter and Transducer assembly shall be as manufactured by Siemens Milltronics HydroRanger 200 with Siemens Milltronics TS-3 remote mounted Transducer/Temperature Sensor (compensator), or Engineer approved equal.

B. L102: General Purpose Ultrasonic Level Transducer Requirements

1. General Requirements for L100 Series Ultrasonic Level Element and Indicating Transmitter apply to this type of instrument.

2. Transducer and Signal Cable shall have the following features:
 - a. Operation:
 - 1) Beam Angle: 3.0 degrees maximum from centerline.
 - 2) Operating Temperature: -40 to +203 degrees Fahrenheit.
 - 3) Span: Refer to Appendix A "Instrument List". Provide transducer from approved series to provide greatest precision within span.
 - b. Enclosure: PVDF, watertight, corrosion resistant, hermetically sealed NEC Class-1 Division-1 rated and submersible.
 - c. Submergence: Skirt/coupling for submergence detection.
 - d. Signal to Transmitter/Controller: 24 volts.
 - e. Cable:
 - 1) Type: RG-62U Coaxial type instrumentation cable, plenum rated as manufactured by Belden, or Engineer approved equal.
 - 2) Length: As required per PLANS for connection to the transmitter/controller without any cable splices. Transmitter may be located up to 1,000 feet from the transducer.
 - f. Mounting: Flange, suspended, or conduit mounting as specifically shown on the PLANS. Provide factory flange adaptor for required installation.
 - g. Connections: 1-inch conduit hub for conduit/wire termination. The use of plastic fasteners or special gaskets to prevent ringing is unacceptable.
3. Ultrasonic Transducer shall be as manufactured by Siemens Milltronics Echomax XPS Series Transducer or Engineer approved equal.

2.04 SUBMERSIBLE PRESSURE TRANSMITTER

A. L207: Requirements:

1. General:
 - a. Shall be designed to operate in Sludge level monitoring application.
 - b. The Submersible Pressure Transducer/Transmitter shall convert the pressure applied to one diaphragm, with the low side open to atmosphere, to a 4 to 20mAdc output signal that is proportional to pressure.
2. The Submersible Pressure Transducer/Transmitter shall have the following features:
 - a. Two-wire 4-20mAdc (loop powered) proportional to head Pressure.
 - b. Minimum range as shown in the Instrument List.
 - c. Transducer shall be suitable for continuous submergence
 - d. Ambient Temperature Range: -40 degrees Fahrenheit to + 185 degrees Fahrenheit,
 - e. Maximum Full Scale Error over Ambient Temperature Range: 3 percent
 - f. Sensor Full Scale Accuracy: plus or minus 0.3 percent of full span
 - g. Transducer Internal Pressure Relief Means: Dedicated breather tube integral with urethane jacketed hose/cable assembly that terminates in a sealed rugged air bladder located inside of the transmitter enclosure.
 - h. Transducer housing: Type 316-Stainless Steel.
 - i. Transducer Diaphragm: Heavy-duty molded Teflon.
 - j. Provide adjustments for field calibration of transmitter signal output
 - k. Indicator Features:
 - 1) Calibrated in "feet and sixteenths of a foot", and to the range of the transmitter.
 - 2) Digital type with Light Emitting Diode (LED), 3.5 digit type with 0.6 inch high digits.

- 3) Input power 24 VDC,
 - 4) Visible through the front door of the transmitter enclosure via a weatherproof clear polycarbonate window
 - 5) Precision digital Model PD6001.
 - l. The Submersible Pressure Transmitter and local indicator shall be enclosed in a NEMA-4X rated enclosure with a hinged door.
 - m. Enclosure shall have internal thermostatically controlled space heater for anti-condensation and freeze protection. Heater shall be rated 120 volts AC.
 - n. Submersible Pressure Transducer/Transmitter interconnect jacketed hose/cable assembly shall have the following features:
 - 1) Polyurethane jacket
 - 2) Contains signal cable and flexible breather tube.
 - 3) Water-resistant.
 - 4) Minimum cable length: Coordinate cable length with the PLANS and provide the length necessary for the application, inclusive of the additional cable that is to be coiled adjacent to the transmitter as shown on the PLANS.
3. Mounting:
- a. Provide cable suspension type mounting with the following features:
 - 1) One (1) mounting Type 316 Stainless Steel pipe (2) feet in length
 - 2) 1/8 inch diameter Type 316 Stainless Steel transducer suspension cable for suspension of transducer. Coordinate cable length with the PLANS and provide the length necessary for the application..
 - b. Provide all necessary Type 316 Stainless Steel hardware to interconnect all components.
 - c. Coil a minimum of 2 feet of slack of breather tubing within the transmitter enclosure.
 - d. Comply with the requirements of the PLANS
 - e. Install in accordance to Manufacturer's recommendations and coordinate final setpoint with the Owner.
4. The Submersible Pressure Transducer/Transmitter, transmitter/indicator enclosure, and all other accessories specified shall be furnished by the same manufacturer. Submersible Pressure Transducer/Transmitters shall be as manufactured by Dwyer Mercoïd, Model PBLT2/x complete with Cable Suspension Mounting Kit Assembly, Digital Indicating Meter and the additional specified accessories, or approved equal.

2.05 ELECTRICAL CONDUCTIVITY ACTUATED LEVEL SWITCH

A. L300 Series General Requirements:

1. General:
 - a. Rods shall be implemented to sense the electrical conductivity of the process media to actuate switches/relays as the process level changes.
 - b. Certifications: The entire electrical conductivity level switch assembly to be U.L. listed.
 - c. Operating Temperature: -40 to +150 degrees Fahrenheit.
 - d. Setpoint elevations will be provided during construction by the OWNER or OWNER Representative. Adjust length of electrode rods, field installed pipe enclosure enclosing electrode rods, and number of conduits straps/supports and electrode spacers as required to accommodate the required setpoints at no additional cost to OWNER.

2. The electrodes shall have the following features:
 - a. Mounting: Set/mount in the field as shown on the PLANS.
 - b. Construction: Solid rod, Type 316 Stainless Steel with Teflon sheath coating.
 - c. Spacers: Teflon spacers with heat shrink installation kits with each spacer installed at no greater than 2 feet on center along length of rods, and at minimum one (1) spacer if total length is less than 2 feet. Spacers shall prevent sway and prevent physical contact with adjacent electrode rods.
 - d. Length: Field cut rods to obtain required height level to suit process setpoints and requirements within a tolerance of 1/8".
 - e. Rod Couplings: Where lengths exceed standard rod lengths, couple multiple rods together with Type 316 Stainless Steel factory provided rod connector couplings with required heat shrink coating to match electrode finish.
 - f. Plugs:
 - 1) Furnish dedicated electrode plug for each level electrode. Each plug shall consist of Type 303 Stainless Steel shell, Teflon insulator, and Teflon seal.
 - 2) Furnish neoprene level electrode field wiring termination plug covers for each electrode plug.
 - g. Electrode Holder:
 - 1) Watertight, made of Type 316 Stainless Steel, threaded male 2" NPT, suitable for two to three (3) electrodes, and to accommodate level electrode(s) physical support, mounting, and field wiring termination as shown on the PLANS.
 - 2) This electrode holder is separate from, and in addition to, the dedicated switch/relay enclosure specified hereinafter.
3. The relay shall have the following features:
 - a. Primary Coil Voltage: 120 VAC.
 - b. Auxiliary Contacts:
 - 1) Furnish each relay with the minimum quantity and type of field selectable Normally Open (N.O.) / Normally Closed (N.C.) auxiliary contacts as required by the PLANS.
 - 2) Furnish one additional field selectable N.O. / N. C. auxiliary contact over and above the number required by the PLANS.
 - 3) All auxiliary contacts shall be rated 10 amps (inductive load) at 120 VAC.
 - c. Resistors: Relay shall have field replaceable resistors to facilitate adjustment of relay level sensing sensitivity. Provide a minimum of 6 unique resistor sizes for each relay to facilitate field calibration of relay level sensing sensitivity.
 - d. Secondary Coil Voltage:
 - 1) Allow for 12, 24, 40, 90, 220, 360, 480, and 800 Volts AC. Voltage shall be factory set.
 - 2) The secondary voltage shall be suitable for the resistance of the process media/liquid being measured.
 - 3) Refer to manufacturer recommended secondary coil voltage for types of fluids and associated fluid resistance values.
 - 4) Review PLANS, select and submit secondary coil voltage for specific fluid and associated resistance compatible with process media/fluid shown on PLANS for this instrument in accordance with manufacturer recommendation for review by Process Mechanical ENGINEER.
 - e. Switch/Relay Enclosure:
 - 1) The switches/relays shall be mounted remotely from their corresponding level electrodes inside a NEMA-4X watertight and corrosion resistant 304 Stainless Steel enclosure.

- 2) Furnish a common enclosure dedicated for each level electrode assembly for the associated level electrode assembly dedicated switches/relays as shown on the PLANS.
4. This enclosure is separate from, and in addition to, the level electrode common junction box previously specified. Also refer to the PLANS. The entire electrical conductivity switch assembly, inclusive of electrode spacers, relay, and all other required accessories shall be furnished by the same manufacturer. Electrical conductivity level switches shall be as manufactured by Ametek B/W Controls, Inc. Series 6012 holder, Series 6013 electrodes, with Series 1500 Relay and the additional specified accessories, or Engineer approved equal.

B. L302: Electrical Conductivity Actuated Two Level Switch

1. General Requirements for L300 Series Electrical Conductivity Actuated Level Switches apply to this type of instrument.
2. Quantity of Levels: Level Switch shall be a two level unit, with two switches and three total rods.

2.06 MECHANICAL LIQUID LEVEL SWITCHES

A. L410 Requirements:

1. The Non-metallic tilting Float Level Switch with non-metallic tilting float shall have the following features.
2. Float Construction: Corrosion resistant PVC
3. Certification: U. L. Listed, suitable for suspension mounting as shown on the PLANS
4. Switch:
 - a. Normally closed hermetically sealed.
 - b. Mounted integrally with float and mechanically activated with float position
 - c. Opens on the level condition as described on the PLANS. Refer to the PLANS.
 - d. SPDT and rated 15 Amp inductive load at 120vac.
 - e. Switch shall not contain mercury.
5. Cable Connection:
 - a. Flexible 14 AWG, 2-conductor SJOW-A water resistant cable integrally connected to float body.
 - b. Of sufficient length to be routed without any splice to the cable termination box as shown in PLANS.
 - c. Coil a minimum of 4 feet of slack of level switch cable within the cable termination box.
6. Weight:
 - a. Field moveable weight installed on the cable for level adjustment.
 - b. Float is to have a minimum "SET-RESET" level differential angle of 85-degrees (plus or minus 5 degrees).
 - c. Weight shall be made of corrosion resistant material

7. Mounting:
 - a. Provide all necessary mounting hardware for a secure installation of level switch complete with all accessories
 - b. Comply with the additional requirements as shown on the PLANS
8. The level switch shall be as manufactured by "SJ Electro Systems, Inc." Series SJE Pump Master Plus with "S.J. Electro Systems, Inc." liquid-Tight round cable connectors (one per float) and S.J. Electro Systems complete Cable Weight Assembly or approved equal.

B. L415 Requirements:

1. The Non-metallic vertical lift rod Float Level Switch with non-metallic float shall have the following features.
2. Certification: U. L. Recognized.
3. Ambient Operation: Designed to operate in up to 125 degrees Fahrenheit water/air ambient conditions.
4. Float:
 - a. Corrosion resistant PVC.
 - b. Field adjustable mounting location along length of rod.
5. Connection: 3/4" NPT conduit connection.
6. Stem:
 - a. Injection molded acetal plastic.
 - b. Allow for a range of 0.75 inches to 6.5 inches of setpoint adjustment.
 - c. Shall have mechanical stop to prevent damage to the switch at the extremes of rod travel.
 - d. Refer to Instrument List as applicable.
7. Switch:
 - a. Refer to the PLANS for contact action with respect to level condition.
 - b. Mounted in a PVC corrosion resistant enclosure.
 - c. SPDT and rated 15 Amp inductive load at 120vac.
 - d. Switch shall not contain mercury.
8. Cable Connection:
 - a. Integral 3 conductor, 16 AWG cable.
 - b. Of sufficient length to be routed, without any splice, to pull box as shown on the PLANS.
 - c. Coil a minimum of 7 feet of slack of level switch cable within the pull box.
9. Mounting:
 - a. Type 316 Stainless Steel mounting bracket.
 - b. Provide all necessary mounting hardware for a secure installation of level switch. All mounting hardware, support channels, and bolts/nuts shall be Type 316 Stainless Steel.
 - c. Provide all necessary mounting hardware for a secure installation of level switch complete with all accessories.

- d. Comply with the additional requirements as shown on the PLANS.
- e. The level switch shall be as manufactured by "SJ Electro Systems, Inc." Series SJE Vertical Master Pump Switch complete with specified accessories or approved equal.

2.07 THERMAL DISPERSION FLOW SWITCH

A. F405: Requirements

1. Flow Switch shall be a thermal dispersion in-line type, with relay and low flow orifice integral in-line fitting.
2. Measurement Characteristics:
 - a. Process Fluid Service: Liquid.
 - b. Flow Setpoint Range:
 - 1) When Inserted in Water: 0.015 to 10 cc/second (0.00024 to 0.16 gpm).
 - 2) Factory Calibration: Calibrate switch setpoint to within +/- 2% error of value shown on Appendix A Instrument List.
 - 3) Flow switch setpoints shall be field adjustable within the range specified above.
3. Operating Conditions:
 - a. Sensor Pressure: Up to 3,500 PSIG at 70 degrees Fahrenheit.
 - b. Operating Temperatures:
 - 1) Sensor: -40 to +350 degrees Fahrenheit.
 - 2) Control Circuit: -40 to +140 degrees Fahrenheit.
4. Materials and Construction:
 - a. Sensor: 316L Stainless steel with all welded construction and in-line process connection Type 316L Stainless Steel tee-fitting and integral low flow Orifice. All wetted parts shall be 316L Stainless Steel.
 - b. Process Connection: 3/4" female NPT pipe connections.
 - c. Electrical Enclosure: Aluminum (epoxy coated), NEMA Type 4X.
 - d. Identification Tag: Type 316L Stainless Steel.
5. Power and Signal:
 - a. Input Power: 120 Volts AC; 13 Watts.
 - b. Signal Relay: SPDT, 6 Amp rated, epoxy sealed.
 - c. Electrical Connection: 3/4" NPT conduit port.
6. Flow Switch Pipe Connection and Mounting:
 - a. Reducer Fitting: Provide a non-Factory furnished process piping reducer fitting as required to connect to process piping size shown on Mechanical PLANS. Reducer fitting pressure rating, material, and joint requirements to match that of process piping to which instrument is connected. Refer to Mechanical piping documents for additional requirements.
7. Each Flow Switch assembly shall be as manufactured by Fluid Components International Series FLT93-L with all specified accessories, or Engineer approved equal.

2.08 PRESSURE SWITCH

A. Type:

1. Diaphragm actuated.

B. Function/Performance:

1. Repeatability: Better than 1 percent of full scale.
2. Setpoint: Field adjustable and set between 30 and 70 percent of the adjustable range.
3. Dead Band: Fixed unless adjustable dead band requirement is noted in the Instrument Device Schedule.
4. Reset: Unit shall be of the automatic reset type unless noted otherwise in the Instrument Device Schedule.
5. Over Range Protection: Over range protection to 150 percent of the maximum process line pressure.
6. Output: Single pole double throw (SPDT) unless requirement for double pole double throw (DPDT) switch is shown on the wiring schematic drawings. Switch rating shall be 10 A at 230 VAC.

C. Physical:

1. Housing: NEMA 316 stainless steel for non-hazardous areas.
2. Switch Assemblies: Hermetically sealed switches.
3. Wetted Parts: Type 316L stainless steel diaphragm, viton seals, Type 316 stainless steel connection port.

D. Accessories/Options Required:

1. Shutoff Valve: Provide a Type 316 stainless steel shutoff valve. Valve shall be by D/A Manufacturing, Anderson Greenwood, or Equal.
2. Where indicated on the instrument device schedule, provide a Type 316 stainless steel snubber for pulsation dampening.

E. Manufacturer(s):

1. Ashcroft.
2. Mercoid.
3. Equal.

2.09 TUBING, HAND VALVES AND FITTINGS

- A. General: Refer to the PLANS for additional requirements for tubing, hand valves, fittings, etc. Provide tubing, hand valves, and fittings for pressure and differential pressure instruments and devices as shown. Provide as required for a functional installation.
- B. Tubing:
 - 1. Material: ASTM A-213 Type 316 Stainless Steel annealed seamless
 - 2. Size:
 - a. Indoor (Inside Building): 3/8" outer diameter tubing with 0.035" wall thickness.
 - b. Outdoor (Outside of Building): 1/2" outer diameter tubing with 0.049" wall thickness.
 - c. Stand Pipe Ventilation or Other System Ventilation Piping: 1" outer diameter tubing with 0.109" wall thickness.
 - d. Provide other larger size(s) as shown on the PLANS.
 - 3. Pressure Rating: 3,000 psi minimum working pressure at 100 degrees Fahrenheit
- C. Metal fittings and Accessories:
 - 1. Type: Swage ferrule design
 - 2. Material: Type 316 Stainless Steel
 - 3. Size: Same size as tubing
 - 4. Pressure Rating: Same as tubing
 - 5. Manufacturer: Crawford "Swagelok", Parker "CPI", Hoke "Gyrolok", or Engineer approved equal.
- D. Valves:
 - 1. Type: Full port ball valves
 - 2. Material: Type 316 Stainless Steel trim and body
 - 3. Seats and packing: Teflon
 - 4. Size: Same size as tubing
 - 5. Pressure Rating: Same as tubing
 - 6. Manufacturer: Parker CPI, Whitey, Hoke, or Engineer approved equal.
- E. Provide stainless steel reducer/transition fittings at instrument/process piping and tubing connections.

F. Bulkhead Fittings:

1. General Requirements:
 - a. Material: Type 316 Stainless Steel trim and body
 - b. Size: Same size as tubing
 - c. Pressure Rating: Same as tubing
 - d. Manufacturer: Parker CPI, Whitey, Hoke, or Engineer approved equal.
2. Tubing to Tubing Unions:
 - a. Fitting: Bulkhead Union, Hoke BU or Engineer approved equal.
 - b. Connection Type, Both Ends: Swage ferrule design
3. Tubing to Test Port:
 - a. Fitting: Bulkhead Union, Hoke BU or Engineer approved equal.
 - b. Connection Type, Both Ends: Swage ferrule design
4. Tubing to Vent Screen Fitting:
 - a. Fitting: Bulkhead Union, Hoke BU with or Engineer approved equal.
 - b. Tubing Connection Type: Swage ferrule design with standard nut.
 - c. Screen Connection Type: Swage ferrule design with knurled nut, Hoke KN or Engineer approved equal.

G. Vent Screen Fittings:

1. Material: Type 316 Stainless Steel trim and body
2. Size: Same size as tubing or pipe vent screen fitting is connected to.
 - a. Available vent screen fitting sizes shall include 1/4", 3/8", 1/2", 3/4", and 1" in diameter.
 - b. Vent screen fitting shall be of equal diameter or the next listed size greater than the tubing/piping the vent screen fitting is connected to.
 - c. Provide reducer fitting between vent screen fitting and tubing/piping as required.
3. Where tubing/piping is larger than 1" diameter, provide 1" size vent screen fitting and necessary reducer fitting to connect to tubing/piping.
4. Pressure Rating: Same as tubing
5. Fitting: Screen, Hoke SCRN or Engineer approved equal.
6. Manufacturer: Parker CPI, Whitey, Hoke, or Engineer approved equal.

H. Provide stainless steel rigid to plastic flexible tubing transitions where shown on PLANS including stainless steel tube inserts and Teflon ferrule compression fitting.

I. Tubing Support System:

1. UNISTRUT Cush-A-Clamp Assembly Pipe/Tube Clamp (1-5/8" Series), or Engineer approved equal, with controlled squeeze shoulder bolt for all clamping of instrument tubing.

2. Refer to Specification Section 16150 "Raceways, Fittings, and Supports" for instrument tubing support channel system additional requirements.

2.10 WIRE MESH GRIP

- A. General: Furnish and install heavy duty wire mesh grip to support suspended floats, transducers, etc. as required. Refer to the details shown on the PLANS. Coordinate size of mesh grip required with cable to be supported. Mesh grip shall have the following features:
 1. Material: Type 316 Stainless Steel
 2. Breaking Strength: 1000 lbs, minimum
 3. Manufacturer: Hubbell- Kellums "Heavy Duty, Single Eye, Closed Mesh, Multi-Weave" model series 024170xx, where "xx" is adjusted according to cable diameter. Coordinate cable diameter with the PLANS.

PART 3 EXECUTION

3.01 STORAGE AND HANDLING

- A. The field instrumentation and control devices shall be handled carefully to prevent damage. Units shall be stored in a weatherproof structure prior to installation.

3.02 INSTALLATION

- A. General: The following apply to all products in this Section:
 1. Furnish and install devices in locations shown, and per the details provided in the PLANS, unless otherwise noted.
 2. Unless otherwise specified, all instrument mounting channels, pipes, pipe caps, etc. shall be Type 316 stainless steel; also, all hardware connecting and securing the mounting hardware and instruments such as nuts, bolts, instrument tubing Cush-A-Clamp Assembly Pipe/Tube Clamp etc. shall be Type 316 Stainless Steel.
 3. All field mounted sensor/control/instrument devices shall be permanently identified. The device designations shall agree with those shown on the PLANS. Each device shall be provided with permanent type identifying nameplate.
 4. Nameplates:
 - a. Type: 3-ply, 1/8" thick, rigid thermoset phenolic resin laminated cellulose paper base engraving stock per ASTM D-709, Type I. Nameplates shall be ASTM Grade ES-1, ES-2, or ES-3 as applicable for the face and lettering colors specified hereinafter. Flexible or acrylic tags will be not be accepted.
 - b. Color: White-Black-White
 - c. Lettering: 1/4 inch height, minimum, engraved through the face layer to the melamine middle layer.
 - d. Accessories: Provide holes for mechanical fastening.

- e. Attachment Means: Securely hang nameplates from each sensor/control/instrument device by a flexible stainless steel snap-on type hanger/key-chain cord (neatly drill a hole through the top of the identification nameplate for this purpose).
5. Submit listing of all field instruments tag numbers for verification by OWNER.
6. Install, set, adjust and test all devices per the requirements of Section 17100 of the Specifications. Also, setpoint values shall be reviewed by and coordinated with the OWNER/ENGINEER.
7. The pressure instruments specified under this Section of the Specifications shall be tested by applying known pressure to each unit prior to installation.
8. The instruments specified under this Section of the Specifications shall be installed and calibrated to match its respective system and per the requirements of the Contract Documents and as recommended by the manufacturers.
9. Verify ranges with Owner and Engineer prior to ordering the Pressure Indicators/Transmitters.
10. Refer to Specification Section 16150 "Raceways, Fittings, and Supports" for instrument support channel system requirements.
11. Make all final connections and terminations per the instrument manufacturers' recommendations.
12. Unit and Range of each instrument from the Instrument shall as listed in the Appendix A Instrument List and shall be clearly noted on the instrument Submittals. Instrument ranges shall be confirmed via the submittal process with the ENGINEER prior to ordering any of the Field Instrumentation and Sensing Devices specified under this Section of the Specifications. Select instruments within approved manufacturer series that provide the greatest level of accuracy within the span of measurements listed in the Instrument List.
13. Submit comprehensive calibration sheets to the OWNER indicating "as found" and "final settings". Submit a typical (blank) field calibration sheets/forms to the OWNER for review and comment prior to utilizing the same for recording calibration parameters. Include final field calibration settings in the Operation and Maintenance Manuals.
14. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.
15. Provide manufacturer's services to perform start-up and calibration/verification.
16. Verify factory calibration of all instruments in accordance with the manufacturer's instructions. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

B. Outdoor Mounted Indicators and Transmitters:

1. Furnish and install an aluminum HOOD on top of Indicator Instruments, Transmitter Instruments, Indicating/Transmitter Instruments and Instrument Elements that are mounted OUTDOORS or below flanges mounted OUTDOORS.
2. Where PLANS indicate the provision of sun-shield and/or HOOD, the requirements of HOOD as noted herein shall apply.
3. Secure HOOD to the indicating and transmitting instruments and/or flange mounting assemblies and provide all additional mounting hardware necessary for the installation of the Hood Assembly.
4. HOOD shall be a fabricated component and shall be fabricated from minimum 0.1" thickness, aluminum alloy 3003-H14 sheet (ASTM B209). All seams or joints of HOOD shall be closed by continuous weld.
5. Secure HOOD to the associated instrument supports utilizing 316 Stainless Steel hardware. The top of the Hood shall clear the top of the associated instrument by 6-inches. The side visors of the Hood shall clear both sides and rear of the associated instruments by 4-inches.
6. Proposed aluminum HOOD shall have a double-wall aluminum construction top plate and a minimum one inch thick phenolic foam insulation board installed between the two top walls/plates. Phenolic foam material shall comply with the following:
 - a. Block shape cut to fit entire double-wall void within the double-wall top plate.
 - b. Shall be rigid, expanded, closed-cell structure in compliance with ASTM C 1126, Type II, Grade 1.
 - c. As manufactured by:
 - 1) Kingspan Tarec Industrial Insulation NV; Koolphen K,
 - 2) Resolco International BV; Insul-phen, or
 - 3) Engineer approved equal.
7. Refer to PLANS for additional requirements for construction and mounting of HOOD.

C. Pressure Instruments:

1. Testing:
 - a. The pressure instruments specified under this Section of the Specifications shall be tested by applying known pressure at 0%, 50% and 100% minimum increments of span to each unit prior to installation.
2. Pressure Indicating/Transmitters Serving Liquid Process Lines:
 - a. Install instruments with instrument tubing such that the elevation of pressure tap(s) on transmitter bottomworks is 3" minimum below the elevation of the pressure tap(s) on the process piping//flow-tube element (i.e. venturi, orifice plate, etc.) served and all instrument tubing is above the transmitter bottomworks pressure tap(s) and sloping up towards the pressure tap(s) of the process piping/flow-tube element served.
 - 1) Exception: Pressure instruments with diaphragm seals can be installed above the pressure taps of the process piping//flow-tube element served. However, all piping between the diaphragm seal and the process pipe shall be horizontal.

D. Ultrasonic Level Element and Indicating/Transmitters:

1. Position and orient instrument beam as required for optimal and most accurate level measurements for well/tank/container application and to reduce interference from side walls of wells/tanks/containers.

E. Level Switches and submersible level transducers:

1. Coordinate with Owner and process/mechanical for all level switch and level transducer elevation requirements prior to installation.

F. Electrical Conductivity Actuated Level Switches:

1. Setpoint elevations will be provided during construction by the OWNER or OWNER Representative. Adjust length of electrode rods, field installed pipe enclosure enclosing electrode rods, and number of conduits straps/supports and electrode spacers as required to accommodate the required setpoints at no additional cost to OWNER.
2. Refer to PLANS for mounting of electrode holder onto field supplied vertical piping around full length of electrodes.
3. Install heat shrink sleeves onto rods to secure electrode rod spacers. Install heat shrink sleeves onto rod connector couplings.
4. Field installed pipe enclosure enclosing electrode rods and the two (2) flanges connecting piping to electrode sensor holder shall be as follows:
 - a. General:
 - 1) PVC materials shall be UV resistant, UL Listed and compliant with requirements of Section 1650 "Raceways, Fittings and Supports".
 - b. Vertical Pipe:
 - 1) Pipe Material: Schedule 80 PVC
 - 2) Provide conduit support straps onto vertical piping along full length of piping at required spacing/intervals according to Section 1650 "Raceways, Fittings and Supports".
 - c. Flanges:
 - 1) Top flange with threaded connection: Schedule 80 UV resistant PVC. Fasten threaded bottom of sensor electrode holder to top flange threaded end. Provide necessary reducer bushings between electrode holder and flange threaded connection.
 - 2) Bottom flange with slip-on connection: Schedule 80 UV resistant PVC. Fasten bottom flange to vertical pipe (housing vertical electrode rods) with slip-on connection and solvent weld. Refer to Section 1650 "Raceways, Fittings and Supports" for additional requirements.
 - 3) Flange Bolting Hardware: Type 316 Stainless Steel
 - d. Reducer Bushings:
 - 1) Material: Schedule 80 UV resistant PVC
 - 2) Install reducer bushings as required sizes between electrode holder and top flange.
 - e. Refer to PLANS for size of piping and flanges.
5. Refer to Mechanical piping documents for additional piping and fitting requirements.

6. Relays/Switches Mounting: The switches/relays within enclosure shall be mounted remotely from their corresponding level electrodes inside the control panel as shown on the PLANS.
 - a. Mount and pre-wire the switches/relays to terminal blocks inside the relay/switch enclosure.
 - b. Label the terminal blocks and tag all wire terminations.

G. Chemical Resistance Coatings:

1. Coating Material:
 - a. Chain-stopped alkyd resin spray-on coating Rust-Oleum brand "Spray – Textured Metallic" or Engineer approved equal.
 - b. Resin shall be applicable onto plastics, bare metal, aluminum, fiberglass, and primed surfaces.
2. Coating Application Requirements:
 - a. Install per manufacturer written requirements.
 - b. Take all necessary safety precautions and provide proper ventilation in space during application.
 - c. Clean the surface from any dirt, grease or chemicals. Do not use solvents to clean surfaces. Rinse and let dry.
 - d. For application onto metal surfaces: Apply full coat of manufacturer recommended primer.
 - e. For application onto plastic (Teflon, etc.) surfaces: Thoroughly wipe down the surface with suitable paint thinner prior to application.
 - f. Provide three (3) full coats of the specified Coating Material. Provide coats within the manufacturer recommended recoat window of time.
3. Coat the following items with the specified Coating Material and in accordance to the above Coating Application Requirements:
 - a. Capillary tubing of Type P134 and Type P137; coat over the factory provided armor protective coat.
4. When applying coating, provide temporary tape or other means to ensure paint is not applied on other components of the instruments that are not to be painted, including, but not limited to, the Transmitter indicator and control buttons.
5. Provide coating with all elements fully assembled together, after all bolts/hardware are in place.
6. Take caution not to scratch/damage the coating in the field. Touch-up any nicks or scratches with three (3) coats minimum.

H. Instrument Tubing: Gas, Liquid, and Capillary Tubing

1. Install tubing and supports so as not to interfere with work space/maintenance access of existing and proposed equipment.
2. Make all instrument tubing system connections air/water tight. Provide proper thread/joint sealant such as Teflon brand strips or other approved sealant where connecting to equipment/accessories/fittings.

3. Requirements herein relate to process pressure port taps/connections shall apply to flow-tube element (i.e. venturi, orifice plate, etc.)connections as well.
4. Tubing Support Systems (for Rigid and Flexible Capillary):
 - a. Clamp all instrument tubing onto channel supports. As a minimum, support and clamp all instrument tubing as follows:
 - 1) Gas and Liquid Tubing: at 2'-6" intervals on horizontal and vertical runs, and no more than 3" from each elbow and tee fitting.
 - 2) Capillary Tubing: at 12" intervals on horizontal and vertical runs.
 - 3) Refer to PLANS for additional support requirements.
 - b. Provide suitable floor mounted or ceiling hung channel support systems necessary for mounting/fastening of instrument tubing.
 - c. Overhead or wall support systems for tubing shall be independent of other conduit/pipe support systems and shall solely support instrument tubing systems.
5. Instrument Tubing Conveying Liquid:
 - a. Pressure port tubing connections to process piping and flow-tube elements shall be installed on the side (spring line) of horizontal process pipes and flow-tube elements.
 - b. Horizontal runs of tubing installed lower than the process pipe tap connection shall be sloped 10% up towards process pipe.
 - c. Tubing installed higher than the process pipe tap connection shall have a vent valve installed at its highest point. Slope tubing 10% up towards valve. Provide additional vent valves at highest points/segments of instrument where air/gas can accumulate.
 - 1) Note:
 - a) Instrument tubing serving pressure indicating/transmitter having no diaphragm seal shall not be installed above the process pipe tap connection. Refer to pressure indicating/transmitter installation requirements.
 - d. Do not install instrument tubing conveying liquids directly over electrical panels/equipment. Provide a 3'-0" distance, as seen in plan view, between liquid filled instrument tubing and electrical power distribution equipment.
6. Instrument Tubing Conveying Air/Gas:
 - a. Pressure port tubing connections to process piping and flow-tube elements shall be installed on the top crest position of horizontal process pipes and flow-tube elements.
 - b. Horizontal runs of tubing installed higher than the process pipe tap connection shall be sloped 10% down towards process pipe connection.
 - c. Tubing installed lower than the process pipe tap connection, shall have a condensate drip leg and drain valve. Drip leg pipe segment shall be 6" long. Install instrument tubing at a 10% slope down towards drip leg.
7. Instrument Capillary Tubing:
 - a. Install instrument capillary tubing such that tubing is not in contact with process piping, ground or equipment.
 - b. Coil excess/slack capillary tubing beneath the pressure transmitter and strap onto support channel with clamp. Take care not to coil tubing at less than the manufacturer recommended radius of curvature, and in no case less than a 6" bending radius.
 - c. Install capillary tubing with strict accordance to manufacturer requirements. Do not excessively bend or exert pressure onto capillary tubing during installation to cause damage to the tubing/seals.

8. Instrument Tubing Cutting and Fittings (Non-Capillary):
 - a. Cut tubing with sharp cutting tool. Do not flatten tubing or in any way distort the manufacturer original tube diameter dimensions.
 - b. File edges of tubing after cutting and remove any filings/shavings prior to making connections.
 - c. Provide elbow fittings, tee fittings, reducer fittings, and valves at tube connections. Bending tubing in lieu of elbow fittings is not acceptable.
 - d. Clean inside of tubes prior to operation. Clean by blowing out to ensure there is no debris in tubes.
- I. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents. Instruments may be shown on the PLANS, in the Specifications or both.

3.03 OPERATION AND MAINTENANCE TRAINING

- A. Start-up Training: Provide required instruction to the OWNER's personnel during start-up period.
- B. Special Training School: Provide services of a factory-trained instructor or instructors for each of the specified and installed Field Instrumentation and Sensing Devices for a total period of not less than two (2) working days for the purpose of instructing the OWNER's personnel in the correct operating and maintenance procedures for all the Field Instrumentation and Sensing Devices specified under this Section of the Specifications and installed in this project. This is in addition to the training requirements defined in other Sections of Division 17 of the Specifications. The date of this school shall be scheduled with the OWNER, but will be after the entire instrument and control system is in operation and respective Operation and Maintenance Manuals have been submitted and revised per ENGINEER comments. Also, refer to the additional training requirements defined in other Sections of Division 17 of the Specifications. Provide one (1) month prior notice to schedule class events with OWNER.

3.04 ADDITIONAL REQUIREMENTS THAT APPLY ONLY WHERE SPECIFICALLY NOTED IN THE APPENDIX A – INSTRUMENT LIST

- A. General: The following are additional requirements that apply only where specifically noted for specific instruments in the Appendix A – Instrument List under the “Additional Requirements” table column heading of the Appendix A – Instrument List. Item shall be included in bid alternate. Reference specification section 01030 "Alternates" for description of alternate bid items that may be included in the accepted bid.

3.05 MEASUREMENT AND PAYMENT

- A. No separate measurement or payment for work performed under this Section. Include cost of same in Contract price bid for work of which this is a component part.

END OF SECTION

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**APPENDIX A -
SOUTH AUSTIN REGIONAL WWTP GRAVITY THICKENER IMPROVEMENTS INSTRUMENT LIST**

| INSTRUMENT TAG | INST. TYPE CODE | SPEC. SECT. | PROCESS AREA | COMPONENT TITLE | MIN. VALUE | MAX. VALUE | MEAS. UNIT | INSTALLATION DETAIL DWG | PLAN DWG | WIRING SCHEMATIC | P&ID DWG | ADDITIONAL REQUIREMENTS |
|-------------------------------|-----------------|-------------|-------------------------------|--|------------|------------|------------|-------------------------|----------|------------------|----------|-------------------------|
| STPB-TIT-9001 | | 17380 | SLUDGE TRANSFER PUMP BUILDING | ELECTRICAL ROOM AMBIENT AIR TEMPERATURE INDICATOR TRANSMITTER | | | | G-I-5 | E-30 | I-9 | I-4 | |
| STPB-FIT-9201 STPB-FE-9201 | | 17381 | SLUDGE TRANSFER PUMP BUILDING | THICKENED SLUDGE PUMPS NO. 1-3 DISCHARGE FLOW INDICATING TRANSMITTER | | | | G-I-4 | E-30 | I-9 | I-3 | |
| STPB-FIT-9202 STPB-FE-9202 | | 17381 | SLUDGE TRANSFER PUMP BUILDING | THICKENED SLUDGE PUMPS NO. 4-6 DISCHARGE FLOW INDICATING TRANSMITTER | | | | G-I-4 | E-30 | I-9 | I-3 | |
| STPB-PSL-9211 | | 17380 | SLUDGE TRANSFER PUMP BUILDING | THICKENED SLUDGE PUMP NO.1 LOW SEAL WATER PRESSURE | | | | Mech. | E-30 | E-42 | I-3 | |
| STPB-PSL-9221 | | 17380 | SLUDGE TRANSFER PUMP BUILDING | THICKENED SLUDGE PUMP NO.2 LOW SEAL WATER PRESSURE | | | | Mech. | E-30 | E-43 | I-3 | |
| STPB-PSL-9231 | | 17380 | SLUDGE TRANSFER PUMP BUILDING | THICKENED SLUDGE PUMP NO.3 LOW SEAL WATER PRESSURE | | | | Mech. | E-30 | E-44 | I-3 | |
| STPB-PSL-9241 | | 17380 | SLUDGE TRANSFER PUMP BUILDING | THICKENED SLUDGE PUMP NO.4 LOW SEAL WATER PRESSURE | | | | Mech. | E-30 | E-46 | I-3 | |
| STPB-PSL-9251 | | 17380 | SLUDGE TRANSFER PUMP BUILDING | THICKENED SLUDGE PUMP NO.5 LOW SEAL WATER PRESSURE | | | | Mech. | E-30 | E-46 | I-3 | |
| STPB-PSL-9261 | | 17380 | SLUDGE TRANSFER PUMP BUILDING | THICKENED SLUDGE PUMP NO.6 LOW SEAL WATER PRESSURE | | | | Mech. | E-30 | E-46 | I-3 | |
| STPB-FIT-9302 STPB-FE-9302 | | 17381 | SLUDGE TRANSFER PUMP BUILDING | THICKENED SLUDGE TRANSFER PUMPS DISCHARGE FLOW INDICATOR TRANSMITTER | | | | G-I-4 | E-30 | I-9 | I-4 | |

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SECTION 17381
MAGNETIC FLOWMETERS

PART 1 GENERAL

1.01 SUMMARY

- A. The work performed under this Section consists of furnishing, installing, calibrating and placing into satisfactory service the following field mounted devices as shown on the PLANS:

1. Electromagnetic Inline Flow Element and Indicating Transmitter

1.02 RELATED REQUIREMENTS

- A. Refer to Specification Section 17380 "Field Instrumentation and Sensing Devices" for additional requirements and the Instrument List.
- B. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
- C. It is the CONTRACTOR's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR's Work.

1.03 SUBMITTALS

- A. Submit the following in accordance with the Section 01300 and 01730 of the Specifications and in accordance to Section 17100 of the Specifications:
1. Shop Drawings and product data.
 2. Submit wiring schematics for all equipment.
 3. Test Reports: Completed and certified factory and field calibration data sheets for instruments and devices that require set-up and calibration.
 - a. Include factory calibration for each instrument with stated accuracy.
 4. Operation and maintenance manuals.
 - a. Include all completed and certified test reports in manuals.
 5. Calibration data:
 - a. Submit a real-time computer generated printout of the actual calibration data indicating apparent and actual flows at 0 percent, 25 percent, 50 percent, 75 percent, 100 percent, 75 percent, 50 percent, 25 percent, and 0 percent, (a 9-point calibration of both ascending and descending directions) of the calibrated range to the ENGINEER at least 30 days before shipment of the meters to the project site.
 - b. Calibration data of flow meters shall include effects of all system subcomponent errors as applicable to the flow meter assembly including, but not limited to flow tube/element errors, upstream and downstream pipe fitting/valves installation errors with length of straight pipes and fitting locations verified with actual/proposed field installed piping conditions, instrument/transmitter errors, signal transmission errors,

diaphragm/pressure seal errors, and ambient and process fluid temperature fluctuation errors. Ambient and process fluid temperature ranges shall be coordinated with Process Engineer,

6. Submit detailed listing of training class curriculum including, as a minimum, the following at least four (4) months prior to class:
 - a. Specific topics for each instrument, including but not limited to, general troubleshooting, calibration, wiring, and general set-up/configuration.
 - b. Anticipated duration of class for each instrument type.
 - c. Names of instructor(s) for each specific instrument.

1.04 QUALITY ASSURANCE

- A. Standardization: All equipment of the same Instrument Type to be the product of a single manufacturer.
- B. Examine the complete set of Contact Documents and verify that the instruments are compatible with the installed conditions including:
 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
- C. Notify the ENGINEER if any installation condition does not meet the instrument manufacturer's recommendations or specifications.
- D. Contractor shall be trained and certified by the Fiberglass reinforced vinyl ester support channel manufacturer in the proper installation of the fiberglass reinforced vinyl ester support channel system.
- E. Material Compatibility:
 1. Material selections of instrument components noted in this section provide a basis for the minimum material compatibility requirements.
 2. Instrument component material selections shall be subject to additional restrictions and compliance with recommendations of instrument manufacturers for the intended service.
 3. Provide instrument component materials in compliance with specific process fluid temperature, pressure, chemical compatibility, and other process fluid parameters.

1.05 ACCEPTABLE MANUFACTURERS

- A. Each type of Instrument shall be manufactured by a single Instrument manufacturer and additional requirements as follows:
1. All flow indicating transmitters shall be manufactured by a single Instrument manufacturer.

PART 2 PRODUCT

2.01 GENERAL

A. Flow Element

1. Type:
 - a. Pulsed DC type.
2. Function/Performance:
 - a. Operating Temperature: Process liquid temperatures of 0 to 140 degrees F or greater dependent upon liner and an ambient of minus 30 to 150 degrees F.
 - b. Radio Frequency Interference (RFI) protection: RFI protection shall be provided as recommended by the manufacturer.
 - c. Pressure rating: Equal to piping system where meter is installed.
 - d. Additional: Meter shall be capable of running empty indefinitely without damage to any component.
3. Physical:
 - a. Metering Tube: Type 304 stainless steel or equivalent.
 - 1) Diameter of meter tube/spool shall be line-sized and same diameter as the process pipe on which meter/element is installed. Refer to PLANS for process pipe diameter/size.
 - b. Flanges: ANSI 150 lb. or DIN PN 16 carbon steel, as required by the piping system, unless otherwise indicated. ANSI 150 lb. or DIN PN 16 stainless steel flanges shall be used on all SS process pipes.
 - c. Liner: Polyurethane or composite elastomer unless otherwise indicated on the Drawings or in the Instrument Device Schedule.
 - d. Electrodes: Type 316 stainless steel standard minimum requirements. All electrodes to be compatible with process fluid as indicated on the Drawings or electrodes to be supplied as listed in the Instrument Device Schedule.
 - 1) Self-cleaning or removable electrode option must be provided with each meter.
 - e. Housing: For meters with remote mounted transmitters, meters below grade shall be suitable for submergence for up to 48 hours to a depth of 30 ft (9m). Meters above grade shall be NEMA 4X (IP65). Where hazardous areas are indicated on the Drawings, the equipment shall be rated for that area.
 - f. Finish: All external surfaces shall have a chemical and corrosion resistant finish.
4. Power Requirements:
 - a. Meter shall be 24 VDC powered instrument, receiving its power from transmitter.

5. Accessories/Documentation Required:
 - a. Factory calibration: All meters shall be factory calibrated. A copy of the calibration report shall be included in the O&M manual.
 - b. Grounding: Meter shall be grounded in accordance with the manufacturer's recommendation. Provide ground ring, ground wires, gaskets, etc., as required. All materials shall be suitable for the liquid being measured and must be compatible with process fluid and with the process pipe.
 - c. For meters with remote mounted transmitters, provide signal cable for installation between the flow tube and the transmitter. Length shall be as required by installation as indicated on the PLANS.

B. Flow Converter/Transmitter

1. Type:
 - a. Micro-processor based, intelligent transmitter compatible with flow tube provided.
 - b. Integral mount or mounted remote from the flow tube as shown on the drawings or as required by the physical location.
2. Functional/Performance:
 - a. Accuracy (including flow tube): Plus/minus 0.5 percent of flow rate or better.
 - b. Operating Temperature: -20 to +140 degrees F.
 - c. Output: Isolated 4-20 mA with HART protocol. Current output adjustable over the full range of the instrument. Provide a dry contact to indicate reverse flow.
 - d. Diagnostics: Self diagnostics with on screen display of faults.
 - e. Display: Digital indicator displaying flow in engineering units indicated in the Instrument Device Schedule.
 - f. Totalizer: A fully configurable totalizer integral to the transmitter. Totalized flow shall be displayed.
 - g. Empty Tube Zero: The transmitter shall include a feature that will lock the output at zero when no flow is detected. The empty tube zero feature shall be enabled automatically when the transmitter detects no flow or manually through a contact input.
 - h. Provide electrode cleaning unit to match flow element requirements.
 - i. Refer to PLANS for additional requirements.
3. Physical:
 - a. Transmitter shall be suitable for surface or pipe stand mounting.
 - b. Enclosure shall be NEMA 4X (IP65).
4. Power Requirements:
 - a. The transmitter shall be 120 VAC powered instrument.
5. Accessories/ Required:
 - a. Keypad where required for transmitter configuration.

C. Refer to PLANS for additional power, control, wiring, I/O point and other requirements.

D. Manufacturer:

1. Provide produce from one of the following:
 - a. ABB Instruments WaterMaster.

- b. Krohne Optiflux 2000 or 4000 Series.
- c. Siemens Sitrans FM MAG.
- d. Rosemount Series 8705 Meter and 8712 Transmitter for remote mounted transmitter, or 8732E meter/transmitter for integral mounted.

PART 3 EXECUTION

3.01 STORAGE AND HANDLING

- A. The instrumentation and control devices shall be handled carefully to prevent damage. Units shall be stored in a weatherproof structure prior to installation.

3.02 INSTALLATION

- A. General: The following apply to all products in this Section:
 - 1. Furnish and install devices in locations shown, and per the details provided in the PLANS, unless otherwise noted.
 - 2. Unless otherwise specified, all instrument mounting channels, pipes, pipe caps, etc. shall be Type 316 stainless steel; also, all hardware connecting and securing the mounting hardware and instruments such as nuts, bolts, instrument tubing Cush-A-Clamp Assembly Pipe/Tube Clamp etc. shall be Type 316 Stainless Steel.
 - 3. All field mounted sensor/control/instrument devices shall be permanently identified. The device designations shall agree with those shown on the PLANS. Each device shall be provided with permanent type identifying nameplate. Nameplates, unless otherwise specified, shall be shaped as a circle and shall be constructed of 3-ply "White-Black-White" laminated phenolic material having engraved letters approximately 1/4 inch high extending through the white face into the black layer. Securely hang nameplates from each sensor/control/instrument device by a flexible stainless steel snap-on type hanger/key-chain cord (neatly drill a hole through the top of the identification nameplate for this purpose).
 - 4. Submit listing of all field instruments tag numbers for verification by OWNER.
 - 5. Install, set, adjust and test all devices per the requirements of Section 17100 of the Specifications. Also, setpoint values shall be reviewed by and coordinated with the OWNER/ENGINEER.
 - 6. The instruments specified under this Section of the Specifications shall be installed and calibrated to match its respective system and per the requirements of the Contract Documents and as recommended by the manufacturers.
 - 7. Verify ranges with Owner and Engineer prior to ordering instruments.
 - 8. Refer to Specification Section 16150 "Raceways, Fittings, and Supports" for instrument support channel system requirements.
 - 9. Make all final connections and terminations per the instrument manufacturers' recommendations.

10. Unit and Range of each instrument from the Instrument List shall be as listed in the Specification Section 17380 "Field Instrumentation and Sensing Devices" Appendix A Instrument List and shall be clearly noted on the instrument Submittals. Instrument ranges shall be confirmed via the submittal process with the ENGINEER prior to ordering any of the Field Instrumentation and Sensing Devices specified under this Section of the Specifications. Select instruments within approved manufacturer series that provide the greatest level of accuracy within the span of measurements listed in the Instrument List.
 11. Submit comprehensive calibration sheets to the OWNER indicating "as found" and "final settings". Submit a typical (blank) field calibration sheets/forms to the OWNER for review and comment prior to utilizing the same for recording calibration parameters. Include final field calibration settings in the Operation and Maintenance Manuals.
 12. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.
 13. Provide manufacturer's services to perform start-up and calibration/verification.
 14. Verify factory calibration of all instruments in accordance with the manufacturer's instructions. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.
- B. Outdoor Mounted Indicators and Transmitters:
1. Furnish and install an aluminum HOOD on top of Indicator Instruments, Transmitter Instruments, Indicating/Transmitter Instruments and Instrument Elements that are mounted OUTDOORS or below flanges mounted OUTDOORS.
 2. Where PLANS indicate the provision of sun-shield and/or HOOD, the requirements of HOOD as noted herein shall apply.
 3. Secure HOOD to the indicating and transmitting instruments and/or flange mounting assemblies and provide all additional mounting hardware necessary for the installation of the Hood Assembly.
 4. HOOD shall be a fabricated component and shall be fabricated from minimum 0.1" thickness, aluminum alloy 3003-H14 sheet (ASTM B209). All seams or joints of HOOD shall be closed by continuous weld.
 5. Secure HOOD to the associated instrument supports utilizing 316 Stainless Steel hardware. The top of the Hood shall clear the top of the associated instrument by 6-inches. The side visors of the Hood shall clear both sides and rear of the associated instruments by 4-inches.
 6. Proposed aluminum HOOD shall have a double-wall aluminum construction top plate and a minimum one inch thick phenolic foam insulation board installed between the two top walls/plates. Phenolic foam material shall comply with the following:
 - a. Block shape cut to fit entire double-wall void within the double-wall top plate.
 - b. Shall be rigid, expanded, closed-cell structure in compliance with ASTM C 1126, Type II, Grade 1.

- c. As manufactured by:
 - 1) Kingspan Tarec Industrial Insulation NV; Koolphen K,
 - 2) Resolco International BV; Insul-phen, or
 - 3) Engineer approved equal.
- C. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents. Instruments may be shown on the PLANS, in the Specifications or both.

3.03 OPERATION AND MAINTENANCE TRAINING

- A. Start-up Training: Provide required instruction to the OWNER's personnel during start-up period.
- B. Special Training School: Provide services of a factory-trained instructor or instructors for each of the specified and installed Field Instrumentation and Sensing Devices for a total period of not less than One (1) working day for the purpose of instructing the OWNER's personnel in the correct operating and maintenance procedures for all Instrumentation and Sensing Devices specified under this Section of the Specifications. This is in addition to the training requirements defined in other Sections of Division 17 of the Specifications. The date of this school shall be scheduled with the OWNER, but will be after the entire instrument and control system is in operation and respective Operation and Maintenance Manuals have been submitted and revised per ENGINEER comments. Also, refer to the additional training requirements defined in other Sections of Division 17 of the Specifications.
 - 1. Provide one (1) month prior notice to schedule class events with OWNER.
 - 2. Submit detailed listing of class curriculum including, as a minimum, with the following at least four (4) months prior to class:
 - a. Specific topics for each instrument, including but not limited to, general troubleshooting, calibration, wiring, and general set-up/configuration.
 - b. Anticipated duration of class for each instrument type.
 - c. Names of instructor(s) for each specific instrument.

3.04 MEASUREMENT AND PAYMENT

- A. No separate measurement or payment for work performed under this Section. Include cost of same in Contract price bid for work of which this is a component part.

END OF SECTION

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SECTION 17600
DISTRUBUTED CONTROL SYSTEM

PART 1 GENERAL

- A. Furnish all labor, materials, equipment, and incidentals required, and shall install complete, ready for operation, and test the distributed control system, hereinafter termed the System as shown on the PLANS and as specified.
- B. The Instrument and Control System Contractor (ICS) shall provide equipment, materials, software, calibrations, training, startup assistance and system check-out, and other services that are required to successfully interface and interconnect the System and associated equipment that are specified or designated in PLANS or provisions of these specifications for the purpose of providing a fully integrated and functional control system as specified.
- C. The subsequent document entitled "Appendix A – South Austin Regional WWTP Gravity Thickener Improvements Proposed PLC Input/Output Schedule" is hereto made part of this section and includes a listing of proposed PLC input/output interface points and other requirements. This schedule in "Appendix A" is not inclusive of all equipment required by this Contract. Refer to other subsections of this Specification Section for additional requirements in addition to those listed in "Appendix A".

1.02 DISTRIBUTED CONTROL SYSTEM DESCRIPTION

- A. General:
 - 1. The Distributed Control System (DCS) as shown on the PLANS and specified herein, includes, but is not limited to, the following:
 - a. Programmable Logic Controllers Subsystem (PLCs),
 - b. Communication System Application and System Software,.
 - c. PLC networking/data communications over existing and proposed Ethernet TCP/IP network
 - d. Interface with Power Monitoring Units, Protective Relays, and other devices as shown on the PLANS.

1.03 RELATED SPECIFICATIONS

- A. Refer to Section 17100.
- B. This Section covers work related to the Distributed Control System DCS and its Subsystems. Note that this Section does not stand alone. Many key technical definitions, functional requirements, training, submittals, etc. requirements for the DCS are given in Section 17100 "Process Instrumentation and Control Systems PICS".

1.04 DISTRIBUTED CONTROL SYSTEM (DCS) SUBMITTALS

- A. General: Submit the following in accordance with the Section 01300 of the Specifications.

- B. Hardware:
 - 1. Shop drawings, product data, bill of materials
 - 2. Control system architecture block diagram,
 - 3. Wiring diagrams
 - 4. Spare parts listing.
- C. Fiber-Optic Cable Plant Design: Submit fiber-optic cable types, installation procedure, and fiber flux budget/gain margin calculations.
- D. Fiber Optic Cable Testing Submittal: Provide a complete set of fiber optic cable test results for the testing required under subsection 3.02 “Fiber-Optic System – Source Quality Control”, this Section of the Specifications. Format and quantity of reports shall be per the requirements of Section 01300 of the Contract Specifications Provide the OWNER with a typewritten results of all tests, including a description of the equipment tested, the date and time of day tested, test values, results. Test reports shall be signed by the ICS representative.
- E. Operations and Maintenance O&M Manuals:
 - 1. Hardware: As minimum, provide the following:
 - a. Final approved versions of all shop drawing submittals.
 - b. Component Manufacturers’ O&M Manuals including manuals to cover installation, operation, maintenance, troubleshooting, and calibration.
 - c. List of spare parts and expendables provided and list of spare parts recommended.
 - 2. Software: As minimum, provide the following:
 - a. the Component manufacturers’ latest version of the programming manuals for the Unity Pro XL Programming interface and IEC programming languages.
 - b. Provide the OIU manufacturers standard programming manuals and latest version of the I/O drivers and the screen development and configuration software.
- F. Refer to submittal requirements of Specifications Section 17100, Section 01300 and Section 01730 of the Contract Specifications.
- G. Configuration System per subsection 2.14, this Section of the Specifications.

1.05 SPARES, EXPENDABLES, AND TEST EQUIPMENT

- A. Provide the following spares and Expendables and Test Equipment at minimum:
 - 1. Provide the following SPARE equipment, complete with all accessories:
 - a. PLC processor units (CPU Modules): One (1) for each type of PLC specified.
 - b. PLC power supply units: Ten Percent (minimum of 1) of the number required for each type of PLC specified
 - c. PLC I/O Module (AI, AO, DI, DO): Ten Percent (minimum of 2) of the number of each type, for each type of PLC specified.
 - d. PLC rack: One (1) for each type of PLC specified.

- e. Ethernet Switch: With exception to those included in the bid allowance (Refer to Section 300L), provide one (1) of each type
- f. Ethernet card: One (1) spare for each type of PLC specified. PLC rack: One (1) for each type of PLC specified.
- g. Ethernet Switches: One (1) of each type provided.
- h. All spare parts shall be of the same manufacturer, model, and software revision as the installed component, and shall be provide complete with all accessories.

PART 2 PRODUCTS

2.01 GENERAL

- A. Refer to Section 17100.
- B. General Requirements:
 - 1. Power source parameters:
 - a. 120 volts A.C., plus or minus 10 percent, 60 Hertz
 - b. Regulators and power supplies required for compliance with the above shall be provided.
 - 2. Materials and equipment used shall be U.L. approved wherever such approved equipment and materials are available.
 - 3. All components and interconnecting wiring shall be provided as required to satisfy the functional and operational requirements of this Specification.
 - 4. All equipment to be installed in a control panel or on a rack, including switches, etc., shall be tagged according to the guidelines outlined in Section 17200 of these Specifications.
 - 5. Unless otherwise specified, tag each outlet face plate with white Label with black lettering of minimum height ¼” where label is TTP Continuous polyester thermal transfer label as manufactured by Tyco, or approved equal, with ribbon and printer by label manufacturer.
 - 6. Communication Cables: Provide all cables for interconnection between all components of the DCS inside the and/or in duct/conduit banks, as applicable. These cables shall include cables to the various Top-End Computers, PLCs I/O racks, power supplies, central processing units, etc. All cables shall be tagged per Section 17200.
 - 7. All equipment cabling, including fiber optic cables, copper Ethernet cable, all patch cords, Remote I/O cabling, video cables, speaker cables, etc., shall be tagged according to the guidelines and tagging labeling system outlined in Section 17200 of these Specifications. For tagging of cables with manufacturer pre-connected cable ends, e.g. patch cords, power cords, etc., furnish and install SP self-laminating polyester labels (minimum 2” long along length of cable) with thermal transfer printable, low profile translucent polyester film with a permanent acrylic adhesive as manufactured by Tyco, or approved equal, with respective printer and ribbon type by label manufacturer. Tag all S.O. type power cords with the tag of the equipment served.

2.02 PROGRAMMABLE LOGIC CONTROLLERS (PLCS)

A. General:

1. Provide all hardware and software features required to make the PLCs totally operational.
2. The PLCs shall include, but not be limited to, the equipment components called for on the PLANS and in these specifications. Capacities and/or quantities shown are minimum. Provide additional capacity or units as necessary to meet the functional requirements.
3. Availability:
 - a. Subsystem Availability Calculation: The Subsystem availability (A) for the PLC's is defined as average of the individual PLC availabilities (Ai) times the nonspecific availability (NA). That is, $A = NA * (A1 * A2 * A3 \dots * An) / n$, where n is the number of PLC's.
 - b. Availability Requirements: The PLC's availability shall be at least 99 percent.
 - c. Component and Backup Definitions: For purposes of the availability calculations, each PLC, each PLC power supply, its process I/O, and data highway interface is considered to be an individual component. There are no backup components.
4. Communications:
 - a. Failure of any PLC or DCS component connected to the communications system network shall not affect the ability of the remaining components on the network to communicate with each other.
 - b. Data Highway DH Link Requirements:
 - 1) Fast Ethernet (100BaseFX), as minimum, with capability for Gigabit Ethernet (1000BaseLX/LH)
 - 2) Minimum operating distance: 10,000 feet
 - 3) Rate: 10/100 Mbps..
 - c. Fiber Optic Link Requirements:
 - 1) Minimum gain margin: 4 dB. The Flux Budget/Gain margin is the difference between the system gain of the fiber-optic transmitter/receiver and the calculated loss budget of the fiber-optic link (fiber-optic cable, connectors, patch cords, and splices) when both are expressed in decibels (dB)).
 - 2) Rate: 1 Gbps.
 - d. All copper Ethernet cables shall have a category 6A RJ-45 connector and category 6A cable. The connector end shall be the Boot type connector and preinstalled by the Ethernet patch cable manufacturer.
 - e. Modbus cables shall be in accordance to the Square D standard for cable pin out and cable type, for the end devices to be interconnected. The cable shall be shielded. Refer to the Square D Modicon Hardware Reference Guide for Modbus serial cable pin out and guidelines.

B. Type 1 Programmable Logic Controllers (PLCs):

1. Each programmable logic controller shall consist of central processor, process controller, power supply, memory, input/output, interconnecting cables, and optional items as specified.

2. Power Supply:
 - a. Manufacturer: Schneider Electric MODICON TSX QUANTUM Automation Series model number 140CPS11420, No Equal.
 3. Central Processor:
 - a. Memory: 3 Mbytes, at minimum
 - b. Ports: 2 Modbus communication ports, 1 Universal Serial Bus (USB) communication port, and 1 Ethernet Modbus TCP/IP port
 - c. Accessories: Provide a 4 Mbyte FLASH Memory Card, as manufactured by the CPU manufacturer.
 - d. Manufacturer: Schneider Electric Modicon Quantum Unity 140 CPU 65260, No Equal
 4. Discrete Input Module DI:
 - a. Manufacturer: MODICON TSX QUANTUM Automation Series Model number 140DAI54000 No Equal.
 5. Discrete Output DO:
 - a. Manufacturer: MODICON TSX QUANTUM Automation Series model number 140DRC83000 No Equal.
 6. Analog Input Module AI:
 - a. Manufacturer: MODICON TSX QUANTUM Automation Series model number 140ACI03000 No Equal.
 7. Analog Output Modules AOs:
 - a. Manufacturer: MODICON TSX QUANTUM Automation Series model number 140ACO02000 No Equal.
 8. Network Option Ethernet (NOE):
 - a. Manufacturer: Modicon TSX Quantum Automation Series NOE 771-01 Module, No Equal.
 9. PLC Racks
 - a. Manufacturer: MODICON TSX QUANTUM Automation Series model number 140XBP01600, No Equal.
- C. Type 2 Programmable Logic Controllers PLCs:
1. Each programmable logic controller shall consist of central processor, process controller, power supply, memory, input/output, interconnecting cables, and optional items as specified.
 2. Power Supply:
 - a. Manufacturer: MODICON M340 Automation Series model number BMX CPS 3500, No Equal.
 - b. Accessories: Provide screw clamp type removable terminal blocks, Modicon M340 model number BMX XTS CPS10 No Equal.

3. Central Processor:
 - a. Memory: 4096 Kbytes, at minimum
 - b. Ports: 1 mini B Universal Serial Bus (USB) port, 1 Modbus communication port, and 1 Ethernet Modbus TCP/IP port
 - c. Accessories: Provide a 16 MB FLASH Memory Card, as manufactured by the CPU manufacturer.
 - d. Manufacturer: Schneider Electric MODICON M340 BMX P34 2020, No Equal.
4. Discrete Input Module DI:
 - a. Manufacturer: MODICON M340 Automation Series Model number BMX DAI 1604 No Equal
5. Discrete Output DO:
 - a. Manufacturer: MODICON M340 Automation Series model number BMX DRA 0805 No Equal.
6. Analog Input Module AI
 - a. Manufacturer: MODICON M340 Automation Series model number BMX AMI 0410 No Equal.
7. Analog Output Module AO:
 - a. Manufacturer: MODICON M340 Automation Series model number BMX AMO 0210 No Equal.
8. Network Option Ethernet (NOE):
 - a. Manufacturer: Modicon M340 Automation Series model number BMX NOE 0100 Module, No Equal.
9. RTD Module:
 - a. Accessories: Provide an RTD extension module for each RTD module provided, model number MODICON model number Telefast ABE-7CPA412. Provide an extender cord, length as required per PLANS, model number BMX FCW series No Equal.
 - b. Manufacturer: MODICON M340 Automation Series model number BMX ART 0414 No Equal.
10. PLC Racks
 - a. Manufacturer: MODICON M340 Automation Series model number BMX XBP 1200 No Equal.
11. PLC Rack Extender Module:
 - a. Accessories: Provide extender cord, length as required per PLANS, manufactured by Extender Module manufacturer, model number BMX XBC series No Equal.
 - b. Manufacturer: MODICON M340 Automation Series model number BMX XBE 1000 No Equal.

2.03 FIBER-OPTIC CABLES AND CONNECTORS AND HARDWARE GENERAL SPECIFICATIONS REQUIREMENTS

- A. General: Provide and install fiber-optic cables, connectors, panels, cords, and enclosures for the Distributed Control System DCS. The ICS shall schematically design the routing and specify

component make and model. The components specified herein shall be provided as minimum for bidding purposes.

- B. Each fiber cable, as depicted on the PLANS, represents a minimum of two (2) fiber strands. A loose tube fiber cable, as depicted on the PLANS, represents the quantity of fiber strands equal to the loose tube fiber strand count as specified in this section of the specifications.
- C. Communication System Data Highway “DH” Fiber-Optic Cable:
1. Type: Single Mode fiber type. Refer to the PLANS.
 2. Cable Type: Loose tube fiber-optic cables
 - a. Fiber Strand Count:
 - 1) Type 1 Fiber-Optic Cable as shown on the contract PLANS: 72 strands
 - 2) Type 2 Fiber-Optic Cable as shown on the contract PLANS: 12 strands.
 - 3) Unless specifically shown as Type 2 cable, all fiber optic cable shall be assumed to be Type 1.
 - b. Construction: Loose tube construction, allowing for thermal expansions and free movement of the fiber within the protective container.
 - c. Protective Coverings: Continuous and be of the same material, free from holes, splices, blisters, and other imperfections.
 - d. Flooding Compound: Applied into the interior of the fiber buffer tubes.
 - e. Strength members:
 - 1) Integral part of the cable construction
 - 2) Sufficient to support the stress of installation and to protect the cable in service.
 - f. Outer cable jacket: polyethylene (PE), except for the fiber that is run inside a building.
 - g. Additional Requirements:
 - 1) Lightning resistant.
 - 2) Fully water blocked.
 - h. Manufacturer: ALTOS loose tube type Fiber-Optic cable as manufactured by Corning Cable Systems LLC, or approved equal.
 3. Optical fibers:
 - a. Coated with a suitable material to preserve the intrinsic strength of the glass.
 - b. Protected by a protective tube, a jacketed strength member, and an exterior jacket.
 4. Fibers that are single-mode shall be solid glass waveguides with the following characteristics:
 - a. Nominal core diameter: 8.3 microns.
 - b. Outside clad diameter: 125 microns.
 - c. Maximum attenuation (1310 nm): 0.5 db/Km.
 - d. Maximum attenuation (1550 nm): 0.4 db/Km.
 5. Glass cladding: Nominally concentric with the fiber core.
 6. Each fiber shall be continuous with no factory splices.
- D. Fiber-Optic Cable Terminations:
1. General:

- a. "Fanned-out" using a Buffer Tube Fan-Out Kit, with each fiber terminated to a connector
 - b. Provide furcation Unit and Loose tube Cable End kits
 - c. Provide single mode kits and multi-mode kits corresponding to the type of fiber optic cable terminated.
 - d. Provide a minimum 20.0-foot coil of spare fiber in each manhole throughout the cable length as well as at each patch panel.
2. Additional Requirements:
- a. Terminate fiber optic cable only at Main Instrument Control Panels, PLC cabinets, and or Patch panels located indoors.
 - b. Terminate all strands of a loose tube fiber optic cable in one, and only one, patch panel.
 - c. All fiber optic cables shall be tested for performance and loss after termination and installation to verify that at least a 4dB power safety margin is obtained between all transmitters and receivers. Test data for each fiber and safety margin calculations for each fiber path shall be provided to the OWNER and ENGINEER after installation to verify conformance with this specification
- E. Fiber-Optic Connectors:
1. General:
 - a. Provide same type mating connectors for the fiber-optic device and the fiber cable end.
 - b. Fiber Strand Connector Type:
 - 1) Terminate each end of each fiber strand of each loose tube fiber cable with a connector.
 - 2) For all Type 1 loose tube fiber cable, furnish and install SC single mode connector at each end of the strand with ultra PC polish and ceramic Zirconia ferrule.
 - 3) For all Type 2 loose tube fiber cable, furnish and install single mode connector at each end of the strand with minimum ultra PC polish and ceramic Zirconia ferrule. Unless connected to fire alarm panel or owner/IT furnished panel, connector type shall be SC.
 - 4) Coordinate with security system contractor for connector type in fiber terminations to security panels.
 - 5) Coordinate with owner for connector type to be used for City of Austin "IT" Fiber-Optic Cable. At minimum, the single mode connectors shall be ultra PC polish with ceramic zirconia ferrule.
 - c. Termination Location: All outdoor Fiber Optic Cable shall be connectorized, at each end of the cable, to a patch panel located inside the building to which the cable is routed.
 - d. Each loose tube fiber strand ends shall be terminated to a patch panel connector panel.
 2. Terminology:
 - a. An "SC-Duplex" connector is two (2) SC connectors abutted next to each other. Hence, a single "SC-Duplex" connector shall carry two fibers. Similarly, a single "SC-Duplex" adapter shall accept two fibers.
 - b. The Insertion loss is the db loss across two(2) connectors, of the same type, which are mated with each other using a fiber optic adapter of that same type

3. Type:
 - a. Use the hot melt type installation for all connectors, except for those patch cords which are to be preconnectorized by the manufacturer. The connector shall conform to the following:
 - 1) Single-mode insertion loss (typical/maximum): 0.2db/0.3db.
 - 2) Multi mode insertion loss (typical/maximum): 0.2db/0.4db.
 - 3) Durability: < 0.2 db per 500 reconnects.
 - 4) Type: Ultra PC polished ceramic zirconia ferrule.

F. Fiber-Optic Patch Panels:

1. General Requirements For Each Patch Panel:
 - a. Each port on a fiber optic patch panel, as depicted on the PLANS, represents an interconnection to a minimum of two (2) fiber strands. Those ports depicted on the PLANS connected to a loose tube fiber cable represents an interconnection to a minimum of the number of fiber strands within the loose tube fiber optic cable, in accordance to the loose tube fiber strand count as specified in this section of the specifications.
 - b. All Fiber Optic Cables shall be attached to connectors that are then manually inserted into adapters on the patch panel. The fiber optic may be attached by a means that is removable in the future, e.g., wire ties.
 - c. Labeling:
 - 1) In addition to the device/wire tagging requirements described in Section 17200, provide additional labels as described below.
 - 2) Overall Connector Panel Labels: Printed on the patch panel case by the Manufacturer. Provide unique, alphanumeric designation.
 - 3) Connector Panel Adapter Label: Each adapter on each Connector Panel shall have clearly labeled, printed, alphanumeric designation that is unique to that Connector Panel and printed on the connector panel by the Manufacturer.
 - d. Each patch panel shall be accompanied with a typed patch panel schedule with the following columns: Adapter ID, Cable Side, User Side, described as follows:
 - 1) adapter ID: The adapter ID shall be of the form XX-YY, where:
 - a) XX is the Connector Panel identifier shown by the panel manufacturer
 - b) YY shall represent the adapter number within the Connector Panel.
 - 2) Cable Side:
 - a) Indicate the source of the fiber optic strands. Use the "patch panel tag"-XX-YY designation where applicable.
 - 3) User Side:
 - a) Indicates the device (PLC, patch panel, etc.) connected to the adapter.
 - 4) A Hard Copy print out of each Patch Panel Schedule shall be provided to the OWNER and ENGINEER. A soft copy on CD-R media of the patch panel schedule shall also be provided to the OWNER and ENGINEER.
 - e. Employ consistent and uniform application of identifier and adapter numbering assignment to individual fiber strands along the entire span and route of each fiber optic cable.
2. Each Type 1 Fiber Optic Patch Panel shall be as follows:
 - a. Mounting: 19" rack mountable, with necessary brackets. Refer to the PLANS.
 - b. Capacity: Up to 12 connector panels

- c. Connector Panels: Minimum of six (6) connector panels, with six (6) SC-Duplex single mode adapters of ceramic type. Furnish and install additional connector panels as required to terminate all fiber strands of cables terminated to patch panel. Refer to PLANS. Unused slots of patch panel shall be covered with blank panels. Commence termination of panels from the left side of patch panel (when viewing front/user accessible side of panel), and leave right most panels un-terminated, where applicable, as spare.
 - d. All unused fiber optic connector ports shall be covered with a dust protector covering provided by manufacturer of connector.
 - e. Manufacturer: Corning Cable Systems LLC, Model CCH-04U, or approved equal.
3. Each Type 2 Fiber Optic Patch Panel shall be as follows:
 - a. Mounting: Wall mounted with necessary mounting bracket kit and any additional accessories.
 - b. Capacity: Up to six (6) connector panels
 - c. Connector Panels: Six (6) connector panel, with six (6) SC-Duplex single mode adapters of ceramic type.
 - d. All unused fiber optic connector ports shall be covered with a dust protector covering provided by manufacturer of connector.
 - e. Manufacturer: Corning Cable Systems LLC, Model WCH-06P, or approved equal.
 4. Each Type 3 Fiber Optic Patch Panel shall be as follows:
 - a. Mounting: 19" rack mountable, with necessary brackets. Refer to the PLANS.
 - b. Capacity: Up to four (4) connector panels
 - c. Connector Panels: Minimum of one (1) connector panel, with six (6) SC-Duplex single mode adapters of ceramic type. Furnish and install additional connector panels as required to terminate all fiber strands of cables terminated to patch panel. Refer to PLANS. Unused slots of patch panel shall be covered with blank panels. Commence termination of panels from the top left side of patch panel (when viewing front/user accessible side of panel), and leave bottom and right most panels un-terminated, where applicable, as spare.
 - d. All unused fiber optic connector ports shall be covered with a dust protector covering provided by manufacturer of connector.
 - e. Manufacturer: Corning Cable Systems LLC, Model CCH-02U, or approved equal.

G. Fiber-Optic Patch Cords:

1. General:
 - a. Use for indoor runs of fiber cable between a fiber-optic device and a fiber-optic patch panel, between adapters on the user side of two patch panels, or between two fiber optic devices.
 - b. All fiber patch cords shall not consist of any splices of the fiber strands
 - c. Each fiber in each patch cord shall be placed in individual tight thermoplastic buffer tubes and protected with kevlar strength members and enclosed with a thermoplastic jacket with an outer diameter of at least 2.5mm.
 - d. Each patch cord shall consist of at least two (2) fibers, according to the fiber count requirements of the communication devices the cable is interconnecting.
 - e. Each patch cord shall be pre-connectorized with the appropriate type connector by the manufacturer.

- f. Provide minimum length of six feet. Provide additional length as required for the application.
 - g. Patch cords shall be selected with connector ends to mate/match the equipment/device/patch panel connector to which they interconnect. Duplex devices/patch panel connectors shall interconnect with duplex patch cords. Patch cord mode type (single mode or multi mode) shall be the same as that of device mode type and fiber patch panel connector connected fiber strand mode type with which patch cord is interconnecting.
 - h. Patch cord Connectors: connectors on each end of fiber optic patch cord shall mate/match that of the device/patch panel connector to which it is interconnecting on that respective end. All connectors shall have ceramic zirconia ferrule. All single mode connectors shall be Ultra PC Polish. The connector mode type (single mode or multi mode) shall be the same as that of the fiber strand of the patch cord.
 - 1) In particular, single mode SC-Duplex to LC-Duplex Single Mode Patch Cords shall have SC-Duplex connector on one end of the patch cord and LC-Duplex with spring on the other. The SC-Duplex connectors shall be single mode, with ceramic zirconia ferrule and Ultra PC polish. The LC-Duplex connectors shall be single mode, with ceramic zirconia ferrule, with an integrally mounted spring, and Ultra PC polish.
 - 2) In particular, single mode SC-Duplex to SC-Duplex Single Mode Patch Cords shall have SC-duplex connectors on both ends of the patch cord. SC-duplex connectors shall be single mode, with Ultra PC polish ceramic zirconia ferrule
2. Single Mode Fiber Optic Patch Cords
 - a. Diameter: 8.3/125 micron
 - b. Type: Single Mode Fiber
 - c. Features: Adhere to the attenuation and bandwidth parameters as previously specified for fiber-optic cable and connectors as described in these specifications.
 3. Multi Mode Fiber Optic Patch Cords
 - a. Diameter: 50/125 micron
 - b. Type: Single Mode Fiber
 - c. Features: Adhere to the attenuation and bandwidth parameters as previously specified for fiber-optic cable and connectors as described in these specifications.
 4. Manufacturer: Corning Cable Systems LLC, Model Zipcord cables, or approved equal.

H. Fiber-Optic Electronic Units

1. Refer to Requirements of Subsection 2.02 of this section of the specification.

2.04 ETHERNET SWITCHES

A. General

1. Provide and install Ethernet switches for the Distributed Control System DCS. The ICS shall schematically design the routing and specify component make and model. The components herein shall be provided as minimum for bidding purposes.
2. All switches shall be provided with the latest firmware from the manufacturer, where applicable.

B. Ethernet Switches

1. The following Ethernet Switches, and SFP AND SFP+ modules mounted within switch type as shown on drawings, shall be provided. Type 1 Ethernet Switch
 - a. Type 1 Ethernet Switch: Cisco WS-C3750X-24S-E
 - b. Type 2 Ethernet Switch: Cisco WS-C2960S-24TS-L
 - c. Type 3 Ethernet Switch: Cisco Industrial Ethernet IE-3000-8TC, with Cisco PWR-IE3000-AC= (120VAC power supply).
 - d. Type 4 Ethernet Switch: Cisco WS-C2960S-48TS-L
2. Each Type 5 Ethernet Switch shall be as follows:
 - a. Power Input: 120 volts A.C., 60 Hz.
 - b. Port Quantity and Type: Eight (8) 10/100/1000BaseTx Gigabit Ethernet ports, one of which is a dual purpose port which the user may elect to use as a 10/100/10000Base TX port or as a socket for an SFP module.
 - c. Module: Provide minimum one (1) SFP 1000BaseLX/LH module with each switch. All SFP modules shall be the 1000BASE-LX/LH Long Haul module with duplex LC single mode connector. Refer to PLANS for additional SFP modules required per switch.
 - d. Mounting: 19 inch rack mounting, unless shown otherwise on the PLANS. Provide mounting brackets and all related mounting hardware to facilitate mounting the switch. Exception: Provide mounting brackets and all related mounting hardware to facilitate mounting the switch on the backplane of the following control panels "FB1-LCP-001", "FB1-LCP-002", "FB1-LCP-003", "FB1-LCP-004", "FB1-LCP-005", "FB1-LCP-005", and "FB1-CP-OIU2".
 - e. Accessories: Provide a one year support contract with the manufacturer, to begin from the time that the system is commissioned and turned over to the OWNER.
 - f. Manufacturer: Cisco Catalyst 2960G-8TC-L, or approved equal.
3. Ethernet Switch Accessories:
 - a. Furnish and install mounting brackets and hardware as required to install each Ethernet Switch according to manufacturer's instructions and requirements.
 - b. Furnish and install all necessary cables, connectors, and terminators as required for a complete and functional installation.

2.05 ETHERNET COPPER CABLES AND CONNECTORS AND HARDWARE GENERAL SPECIFICATIONS REQUIREMENTS

A. General:

1. Provide and install copper cables, connectors, patch panels, and cords for the Distributed Control System DCS. The ICS shall schematically design the routing and specify component make and model. The components herein shall be provided as minimum for bidding purposes.
2. Ethernet Copper Connectors: All copper Ethernet cables shall have a Category 6A boot type RJ-45 connector.
3. The installed Ethernet copper media system (including cable, data outlets, connectors, patch cords, patch panels, etc.) shall at minimum meet the TIA/EIA-568-C.2-10 Category 6A standards.

B. Ethernet Copper Patch Cords

1. The Ethernet Copper Patch Cord shall be used to connect a communication device with a patch panel or Ethernet Copper Data Outlet. The Ethernet Copper Patch Cord shall also be used to connect devices directly to one another. At minimum, furnish and install copper patch cords for all Ethernet cabling between devices or between device and patch panel within the same cabinet. Refer to PLANS for required interconnections.
2. Each patch cord connector end shall be RJ-45 and shall be the Boot type connector. The connectors at each end shall be preinstalled by the Ethernet patch cord manufacturer.
3. The Patch Cord shall be unshielded twisted pair and shall be rated Category 6A.
4. The Ethernet copper cable outer jacket shall be Blue.

C. Ethernet Copper Patch Panels

1. General Requirements for each patch panel:
 - a. Approvals: Meet or exceed requirements for Category 6A per TIA/EIA-568-C.2-10.
 - b. In addition to the device/wire tagging requirements described in Section 17200, provide additional labels as described below.
 - 1) Overall Connector Panel Labels: Printed on the patch panel case by the Manufacturer. Provide unique, alphanumeric designation.
 - 2) Connector Panel Adapter Port Label: Each adapter port on each Connector Panel shall have clearly labeled, printed, alphanumeric designation that is unique to that Connector Panel port and printed by the patch panel manufacturer.
 - 3) Terminate copper cabling to patch panel in accordance to TIA/EIA-568-C.2-10 standards
 - 4) Label each port of each patch panel. Furnish and install TTP Continuous polyester thermal transfer label as manufactured by Tyco, with ribbon and printer by label manufacturer. Label shall be white with black lettering of minimum height 1/4".
 - c. Each patch panel shall be accompanied with a typed patch panel schedule with the following columns: Adapter ID, Cable Side, User Side, described as follows:
 - 1) adapter ID: The adapter ID shall be of the form XX-YY, where:
 - a) XX is the Connector Panel identifier shown by the panel manufacturer
 - b) YY shall represent the adapter number within the Connector Panel.
 - 2) Cable Side:
 - a) Indicate the source of the fiber optic strands. Use the "patch panel tag"-XX-YY designation where applicable.
 - 3) User Side:
 - a) Indicates the device (PLC, patch panel, etc.) connected to the adapter.
 - 4) A Hard Copy print out of each Patch Panel Schedule shall be provided to the OWNER and ENGINEER. A soft copy on CD-R media of the patch panel schedule shall also be provided to the OWNER and ENGINEER.
 - 5) Employ consistent and uniform application of identifier and adapter numbering assignment to Ethernet Copper cables along the entire span and route of each copper cable.
2. Each Type 1 Copper Patch Panel shall be as follows:
 - a. Construction: Metal, primed and painted with manufacturer's standard black finish.

- b. Quantity of Ports: minimum 24.
 - c. Miscellaneous: Color coded front port labeling.
 - d. Mounting: 19" rack mountable. Mount on 19" rack, with all necessary brackets and hardware. Refer to the PLANS.
 - e. Manufacturer: Siemon, Panduit, Hubbell, CommScope, or approved equal .
3. Each Type 2 Copper Patch Panel shall be as follows:
 - a. Construction: Metal, primed and painted with manufacturer's standard black finish.
 - b. Quantity of Ports: 12.
 - c. Miscellaneous: Color coded front port labeling
 - d. Mounting: Mount on the backplane of the control cabinet. Provide mounting brackets and all related mounting hardware to facilitate mounting the patch panel on the backplane. Refer to the PLANS.
 - e. Manufacturer: Siemon, Panduit, Hubbell, CommScope, or approved equal.
 4. Each Type 4 Copper Patch Panel shall be as follows:
 - a. Construction: Metal, primed and painted with manufacturer's standard black finish.
 - b. Quantity of Ports: minimum 48. Should quantity of cable terminated to a patch panel exceed the port count of patch panel, furnish and install additional patch panels with 48 ports to accommodate all Ethernet cables (one patch panel port per cable) with an additional 12 spare/unused ports ready for future Ethernet cable terminations.
 - c. Miscellaneous: Color coded front port labeling.
 - d. Mounting: 19" rack mountable. Mount on 19" rack, with all necessary brackets and hardware. Refer to the PLANS.
 - e. Manufacturer: Siemon, Panduit, Hubbell, CommScope, or approved equal.

D. Ethernet Data Outlets:

1. Faceplates shall be available with multiple module spaces for both vertical and horizontal applications.
2. Each faceplate shall accept individual modules for both copper and fiber optic applications.
3. Faceplates shall be flush mounted with a clean look and be available with labels.
4. Faceplate color shall be white.
5. For each faceplate, furnish and install a minimum of two (2) MINI-COM TX6A 10GIG Keyed UTP Jack Modules as manufactured by Panduit, or approved equal.
6. Data outlet faceplate shall be manufactured by Panduit model CFPL4, or approved equal, with Four Module Space, with white color. The top two spaces shall be occupied by the specified mini com 10Gb data devices, the bottom two spaces shall be covered with mini com blanks for future use.
7. Furnish and install data label with plastic cover as manufactured by Panduit, or approved equal. Provide label and clear plastic cover as manufactured by Panduit, or approved equal, for all mini com module spaces, even the unused, blank spaces. Label each non-blank device data outlet on each face plate with indelible, permanent printing system with black color imprinted ¼" high capital lettering attached to faceplate and covered by plastic clear cover, as manufactured by Panduit, or approved equal.

8. Submit proposed data labeling for review and approval by owner and engineer prior to commencing data labeling.
9. All data outlet assemblies, including face plate, connector, labels, etc. shall be by one and the same manufacturer.
10. Clearly distinguish SCADA data outlets from other data outlets using color coded mini com data outlet color and faceplate icon color. Coordinate with owner for color preference of the data outlets and icons.

E. Copper Ethernet Data Communication Cabling:

1. Copper Ethernet Communication Cabling shall be used to interconnect copper patch panels with each other, or to interconnect Ethernet data outlets to copper patch panels.
2. The copper Ethernet cabling shall be unshielded, twisted pair, rated Category 6A cabling.
3. Agency Compliance: TIA/EIA-568-C.2, TIA/EIA-568-C.2-10 Category 6A, IEEE 802.3an 10GBASE-T Ethernet, UL Listed
4. Number of Pairs: Four
5. Wire: #23 AWG Bare Copper
6. Type of Conductors: solid copper conductors, twisted
7. Individual Conductor Insulation: minimum 300 volt polyolefin
8. Individual Conductor Insulation Color: White/Blue Stripe, Blue, White/Orange Stripe, Orange, White/Green Stripe, Green, White/Brown Stripe, Brown
9. Overall Jacket: PVC, include ripcord
10. Overall Jacket Color: Blue.
11. Manufacturer: Belden 10GX32, or approved equal.

F. Copper Ethernet Cable System Testing

1. After installation of Copper Ethernet Cable System, ICS shall perform testing of the cable system to assure compliance of the installed system with the TIA/EIA-568-C.2-10 Category 6A requirements. Testing shall be performed for all installed copper cable systems, including used and unused links, from end-to-end, including all data outlets, connectors, patch panels, patch cords, etc.
2. Copper Ethernet Cable System Test reports shall be submitted to the engineer and owner for review and approval. The test report shall document, for each copper data link, description of the link and components therein, the testing method used, test results, and demonstrate compliance with TIA/EIA-568-C.2-10 of the link. If any installed link does not meet the TIA/EIA-568-C.2-10 Category 6A requirements, ICS shall repair/modify link

to assure it is compliant with TIA/EIA-568-C.2-10 Category 6A standard at no additional cost to the owner.

2.06 LAPTOP PROGRAMMING COMPUTER

- A. The Laptop Programming Computer equipment:
 - 1. Dell Latitude E5530
 - 2. Operating Systems Windows 7 Professional, No Media, 32-bit, English
 - 3. Processor 3rd gen Intel® Core™ i7-3520M Processor (2.9GHz, 4M cache, Upgradable to Intel® vPro™ technology)
 - 4. Memory 4.0GB, DDR3-1600MHz SDRAM, 1 DIMM
 - 5. Dell Backpack

2.07 CONFIGURATION SYSTEM

- A. Provide a configuration system, including hardware, system software, and other software necessary to allow Engineer configuration of and programming of the PLC system. PLCs equipment provided as part of the Configuration System shall be fully compatible with the DCS equipment provided for this system and as further identified in this specification.
- B. Deliver the Configuration System at the Engineer's designated facility.
- C. Include at least the following components for the Configuration System:
 - 1. All proposed Programmable Logic Controllers (PLCs), including all racks, power supplies, microprocessor modules, I/O modules, communication modules, remote I/O modules, etc.
 - 2. All proposed Remote I/O units, including all racks, power supplies, I/O modules, communication modules, remote I/O modules, etc.
 - 3. All Communications interface hardware, cabling, and fiber optics electronics for PLC-to-PLC interface, and PLCs to programmer PC interface.
 - 4. All necessary power and communications cabling to interconnect the equipment at the engineer's site. The programming cabling between the PLC and the laptop shall, at minimum, consist of one (1) USB programming cable, of 12 foot length minimum.
 - 5. All spare racks CPUs, I/O cards etc.
 - 6. Provide the following per specifications, to be included with the configuration system (These units may be counted amongst the spare units.):
 - a. One (1) GE Multilin EPM 9450 (Transducer Module) complete with three line LED combination display and keypad Model PL900040N. Furnish and install all required cabling to power the units and to interconnect display with EPM 9450 unit. This spare equipment is furnished for the Motor Control Centers per the PLANS.
 - 7. Provide two (2) CPU memory cards of the type SRAM Memory Card; up to 2MB for Application Storage; and up to 1.8MB for Data Storage.
 - 8. Provide laptop programming computer as further identified in this specification.

9. With exception to those items in packaged system vendor control panels, provide the following:
 - a. Provide all Ethernet Switches
10. Provide 19" rack(s) and install PLC racks and other configuration equipment on 19" rack(s). For each 19" rack, secure rack to base with four (4) lockable, caster wheels that shall allow the cabinet to be pushed/carted forward, backward, and rotated at least 90 degrees. Overall rack assembly height shall not exceed 60".
11. Prior to assembly and delivery of configuration system, submit to engineer a drawing detailing the front and back elevations of proposed arrangement of PLC equipment on 19" rack(s). Upon approval of submittal, contractor is to then configure rack according to approved submittal and ship configuration system to Engineer's location.
12. When directed by the Engineer, recreate and ship Configuration System from the Engineer's designated facility to Owner's facility.
13. Provide property and shipping insurance and include the Engineer and Owner as insured. Insure against fire and all-risk for physical loss and damage. The Owner and Engineer will not provide insurance for the Configuration System.

2.08 UNINTERRUPTIBLE POWER SUPPLIES (UPS)

- A. Furnish and install a UPS inside the control panel enclosure where shown on the PLANS. Each UPS shall be as follows:
 1. General:
 - a. Apparent Power: Provide for the maximum connected load and as shown on the PLANS.
 - b. Run Time (without input power): Minimum duration of fifteen (15) minutes in the event of permanent power loss to the UPS AC input with the UPS serving all connected load at full load.
 - c. Power Factor: greater than 0.9
 - d. Operating Temperature Range: 0 - 40 °C, with relative humidity of 20 - 90%.
 - e. Storage Temperature Range: -20 - 40 °C, with relative humidity of 20 - 90% (without condensation).
 - f. Provide additional features as shown on the PLANS..
 2. Input:
 - a. Input Voltage: 120 volts AC, 60 Hz.
 - b. Connections: Integral AC power cord with ground.
 3. Output:
 - a. Wave form: Continuous, 120 volts AC, 60Hz. sine wave.
 - b. Voltage distortion: 5% at full load, maximum
 - c. Filtering: Filtered with 0.3% IEEE surge let-through and zero clamping response time, complying with UL 1449 requirements.
 - d. Connections: Minimum of four 120VAC, (4) 15A output receptacles, at minimum. Coordinate the receptacle configuration with that required by the external maintenance bypass switch.

4. Batteries:
 - a. Type: Maintenance-free, fumeless, sealed, leak proof battery that is accessible for replacement by the OWNER. The batteries shall be rated for use in Computer Rooms (by NFPA and all other Safety Codes).
 - b. Recharge Rate: Maximum of five (5) hours to charge to 95 percent capacity.
 - c. Provide battery extension cabinet where required to obtain a minimum duration runtime of fifteen (15) minutes for the connected load in the event of a power loss and where shown on the PLANS.

5. External Maintenance Bypass Switch:
 - a. The UPS shall be provided with a manufacturer's standard external maintenance bypass switch. The external maintenance bypass switch shall be sized such to carry the full load current of the UPS inclusive of inrush current, at minimum. Also refer to the requirements shown on the PLANS. The maintenance bypass switch shall be installed in such a manner that the selector switch is accessible from the front of the control cabinet. Provide any additional accessories necessary to facilitate the installation of the maintenance bypass switch.

6. Features:
 - a. The UPS shall consist of a field configurable bypass mode for automatic or manual bypass to the AC input source.
 - b. The UPS shall consist of automatic self test, executed on start up and at regular intervals (minimum of once per 14 days), and fault detection LED annunciating self test failure.
 - c. The UPS shall consist of automatic voltage regulation to maintain its sine wave output in accordance to these specifications. The settings for the UPS AC input source voltage high and low values to initiate transfer to battery power shall be field adjustable.

7. Indications (LED type) and alphanumeric display:
 - a. UPS On Status
 - b. Fault
 - c. On Battery.
 - d. Bypass
 - e. Battery Replacement Needed.

8. Audible Alarms:
 - a. UPS failure
 - b. Battery failure
 - c. Power loss to the UPS.

9. Push Buttons:
 - a. Energizing UPS.
 - b. De-energizing UPS
 - c. Manual UPS Self test initiation.

10. Warranty: Two (2) year manufacturer's warranty

11. Accessories:
 - a. The UPS shall consist of a relay I/O module which provides 24VDC, 1A rated relay output contacts. At minimum, the card shall consist of a dry contact indicating UPS

fault, a dry contact indicating requirement for Battery Replacement, and a dry contact indicating that the UPS is in Bypass. Wire the UPS fault alarm, the battery replacement alarm, and the UPS in bypass status in series to a 24VDC rated type III control relay as specified in section 17200. An alarm contact from the 24VDC UPS fail relay shall be wired as a discrete input into the programmable logic controller to indicate a UPS common trouble/fail alarm. Also refer to PLANS for wiring to the UPS relay I/O module.

- b. The UPS shall be provided with all necessary interconnecting cables, connectors, Windows compatible configuration software (if necessary), for a complete and functional installation.

12. Mounting:

- a. Provide all 19 inch rack mounting brackets, miscellaneous mounting hardware to facilitate the mounting shown on the PLANS. Provide for the mounting configuration as shown on the PLANS. Mount UPS within the control cabinet, without obstructing access to components within cabinet. Install UPS in accordance to manufacturers requirements and recommendations, including proper UPS power termination, ventilation, and cooling.

13. Manufacturer: Eaton Model EX Series UPS with external maintenance bypass switch Eaton HotSwap MBP Model EHBPL****R-PDU1U (where **** is based on UPS rating), and Relay Interface Card Eaton Model No. 9120 , or approved equal.

PART 3 EXECUTION

3.01 GENERAL INSTALLATION

- A. The ICS shall furnish labor, materials, equipment, and incidentals required to install the system in accordance with this specification and specification section 17100.
- B. The ICS shall be responsible for ensuring that field wiring for power and signal circuits is correct and wired in accordance with best industry practice. Also, the ICS shall be responsible for providing all necessary system grounding to insure a satisfactory functioning installation.

3.02 FIBER-OPTIC SYSTEM - SOURCE QUALITY CONTROL

A. Fiber Optic On-Site Testing:

1. General: The ICS shall provide all equipment, instrumentation, and supplies necessary to perform all testing. The OWNER/ENGINEER shall have the option to witness and participate actively in the On-Site tests performed by the ICS firm.
2. Cables shall be tested with an Optical-Time-Domain Reflectometer "OTDR", as described hereinafter. The OTDR shall be designed to test the type of cable required for the project and shall include a laser light source used for transmitting test signals through the fiber under test. Contractor shall use launch cables of minimum length of 500 feet when performing testing with the OTDR. OTDR test wavelengths shall be as follows:
 - a. Single mode cable: 1310 nm and 1550 nm
 - b. Multi-mode cable: 850nm and 1300nm.
3. OTDR test results shall include the following, at minimum:

- a. Cable tested
 - b. Fiber number
 - c. Direction of test
 - d. Wavelength
 - e. Reference power reading,
 - f. Total length of fiber
 - g. Attenuation of the fiber
 - h. Power loss (in dB) across the length of fiber cable
 - i. OTDR traces, legibly plotted
 - j. Additional information as necessary to determine insertion loss across the connectors and cables.
4. Pre-installation testing: Prior to the physical placement of the fiber optic cable, each fiber shall be OTDR tested on-Site, while on the spool. Submit test results for approval prior to cable installation.
5. Post-installation Testing:
- a. Separate OTDR tests shall be performed on all installed fibers (both used and unused fibers) as follows, with all test results submitted accordingly:
 - 1) Cable after connectorization. Perform test from both ends of the cable, at each patch panel connector attached to the cable's fiber strands.
 - 2) Fiber end-to-end attenuation. Test shall be performed on all installed fibers (both used and unused fibers) after connectorization from both ends of the cable, at each patch panel connector attached to the cable's fiber strands
 - 3) Fiber device-to-device attenuation testing. Perform after all necessary patch fiber patch cords have been installed in the system. This test shall be performed on each fiber optic device-to-device link. A device-to-device link is a fiber optic link which connects two (2) opto-electronic devices via a passive fiber optic network consisting of a series of patch cords, loose tube fiber optic cable strands, and patch panel adapters with mating fiber connectors. The test shall be conducted only after all necessary patch cords to be used in the final system are properly installed. The test shall be performed from both ends of each such device-to-device link. The test should include all installed components of each device-to-device link, excluding the opto-electronic devices themselves.

3.03 TESTS (GENERAL)

- A. Refer to Section 17100.

3.04 INITIAL ON-SITE SYSTEM DEMONSTRATION TESTS

- A. Programmable Logic Controllers PLCs:

1. Test all loop-specific functions and demonstrate all I/O Points.
2. Test all non-loop-specific functions including, but not limited to, the following:
 - a. Failure Mode and Backup Procedures: Power failure, auto restart, retentive outputs.
3. Refer to Section 17100 for additional test requirements.

3.05 OPERATIONAL READINESS TEST (ORT) AND PERFORMANCE ACCEPTANCE TESTS (PAT)

- A. Refer to Section 17100.

PART 4 TRAINING

4.01 GENERAL.

- A. Provide a training program for the OWNER's personnel to address all equipment provided. The training program shall meet the specific needs of the OWNER and include the following subjects, at a minimum:

1. Hardware
 - a. Specific training for the actual hardware configuration provided
 - b. Test, adjustment, calibration, troubleshooting, and component replacement procedures.
2. Software
 - a. Operate the equipment on a day-to-day basis.
 - b. Make programming changes for all aspects of programming/configuration/functionality.
 - c. Configuration, troubleshooting, software installation procedures.
 - d. Assist the hardware maintenance technicians in diagnosing problems with the equipment.

- B. Additional training program requirements:

1. Training duration:
 - a. Hardware: A minimum of one (1) week, 40 consecutive normal working hours.
 - b. Software: Provide a minimum of four (4) weeks, 160 consecutive normal working hours. Include:
 - c. Modicon Unity Pro XL PLC programming software (for PLCs): A minimum of one (1) week, 40 consecutive normal working hours.
 - d. GE Fanuc iFix SCADA server and configuration software: A minimum of one (1) week, 40 consecutive normal working hours.
 - e. General Software Training: A minimum of one (1) week, 40 consecutive normal working hours..
 - f. Provide additional time as required by the OWNER.
2. Training Location: OWNER's designated facility located in Austin, Texas. Include all associated expenses.
3. Shift Quantity: Total of two shifts, at minimum, with a minimum eight (8) of the Owners personnel for each shift. Provide the training coordinated with the OWNER's schedule.
4. Personnel attending the training will be technical, managerial, administrative, engineers, and maintenance type personnel. The training shall accommodate instruction methods and materials accordingly.

4.02 MEASUREMENT AND PAYMENT

- A. No separate measurement or payment for work performed under this Section. Include cost of same in Contract price bid for work of which this is a component part.

END OF SECTION

**APPENDIX A -
SOUTH AUSTIN REGIONAL WWTP GRAVITY THICKENER IMPROVEMENTS
PROPOSED PLC INPUT/OUTPUT SCHEDULE**

SLUDGE TRANSFER PUMP BUILDING

| I/O IDENTIFIER | DESCRIPTION | PANEL | RACK | MODULE | PT. |
|-------------------------|--|--------------|-------------|---------------|------------|
| STPB-STPB-PB+01_LI_01 | SLDG HOLDING TANK LEVEL | RIO2A | PLC-001 | AI-1 | 01 |
| STPB-STPB-PB_01_FI_01 | SLDG HOLDING TANK AIR FLOW | RIO2A | PLC-001 | AI-1 | 02 |
| STPB-STPB-PB_01_ZI_01 | SLDG HOLDING TANK AIR FCV POSITION | RIO2A | PLC-001 | AI-1 | 03 |
| STPB-STPB-PB_01_FI_09 | SLDG XREFR PUMP FLOW (TO HORNSBY BEND) | RIO2A | PLC-001 | AI-1 | 04 |
| STPB-STPB-PB_01_AI_20 | SLDG XREF BLDG COM GAS | RIO2A | PLC-001 | AI-1 | 05 |
| STPB-STPB-PB_02_AI_20 | SLDG XREF BLDG COM GAS | RIO2A | PLC-001 | AI-1 | 06 |
| STPB-STPB-YS-TIT-9001 | ELECTRICAL ROOM AMBIENT AIR TEMPERATURE | RIO2A | PLC-001 | AI-1 | 07 |
| STPB-STPB-YS-FIT-9302 | SLUDGE TRANSFER PUMP DISCHARGE FLOW | RIO2A | PLC-001 | AI-1 | 08 |
| STPB-YA-UPS-AC-OFF | DP002A REMOTE UPS AC OFF | RIO2A | PLC-001 | DI-1 | 01 |
| STPB-YA-PSLA | DP002A LOW BATTERY ALARM | RIO2A | PLC-001 | DI-1 | 02 |
| STPB-YA-PS | 24VDC POWER SUPPLY FAIL ALARM | RIO2A | PLC-001 | DI-1 | 03 |
| STPB-YA-PMU-MCCSGT1 | STPB-PMU-MCCSGT1 POWER SYSTEM FAIL ALARM | RIO2A | PLC-001 | DI-1 | 04 |
| STPB-SPARE-1-PLC1-DI-01 | SPARE | RIO2A | PLC-001 | DI-1 | 05 |
| STPB-SPARE-2-PLC1-DI-01 | SPARE | RIO2A | PLC-001 | DI-1 | 06 |
| STPB-STPB-PB_01_ASH_20 | SLDG XFER BLDG COMB GAS LEVEL HIGH | RIO2A | PLC-001 | DI-1 | 07 |
| STPB-STPB-PB_02_ASH_20 | SLDG XFER BLDG H2S GAS LEVEL HIGH | RIO2A | PLC-001 | DI-1 | 08 |
| STPB-STPB-PB_01_LSH_20 | SLDG XFER BLDG SUMP LEVEL HIGH | RIO2A | PLC-001 | DI-1 | 09 |
| STPB-STPB-PB_01_PSL_20 | SLDG SFER BLDG COMPRESSED AIR PRESS LOW | RIO2A | PLC-001 | DI-1 | 10 |
| STPB-SPARE-3-PLC1-DI-01 | SPARE | RIO2A | PLC-001 | DI-1 | 11 |
| STPB-SPARE-4-PLC1-DI-01 | SPARE | RIO2A | PLC-001 | DI-1 | 12 |
| STPB-SPARE-5-PLC1-DI-01 | SPARE | RIO2A | PLC-001 | DI-1 | 13 |
| STPB-SPARE-6-PLC1-DI-01 | SPARE | RIO2A | PLC-001 | DI-1 | 14 |
| STPB-YL-SPDPDP1 | STPB-SPD-PDP1 IN SURGE STATUS | RIO2A | PLC-001 | DI-1 | 15 |
| STPB-YA-SPDPDP1 | STPB-SPD-PDP1 FAIL ALARM | RIO2A | PLC-001 | DI-1 | 16 |
| STPB-YS-ATS1E | STPB-ATS-001 EMERGENCY POWER STATUS | RIO2A | PLC-001 | DI-2 | 01 |
| STPB-YS-ATS1N | STPB-ATS-001 NORMAL POWER STATUS | RIO2A | PLC-001 | DI-2 | 02 |
| STPB-SPARE-1-PLC1-DI-02 | SPARE | RIO2A | PLC-001 | DI-2 | 03 |
| STPB-YA-PMU-MCCSGT2 | STPB-PMU-MCCSGT2 POWER SYSTEM FAIL ALARM | RIO2A | PLC-001 | DI-2 | 04 |
| STPB-SPARE-2-PLC1-DI-02 | SPARE | RIO2A | PLC-001 | DI-2 | 05 |

SLUDGE TRANSFER PUMP BUILDING

| I/O IDENTIFIER | DESCRIPTION | PANEL | RACK | MODULE | PT. |
|--------------------------|--|-------|---------|--------|-----|
| STPB-SPARE-3-PLC1-DI-02 | SPARE | RIO2A | PLC-001 | DI-2 | 06 |
| STPB-SPARE-4-PLC1-DI-02 | SPARE | RIO2A | PLC-001 | DI-2 | 07 |
| STPB-SPARE-5-PLC1-DI-02 | SPARE | RIO2A | PLC-001 | DI-2 | 08 |
| STPB-SPARE-6-PLC1-DI-02 | SPARE | RIO2A | PLC-001 | DI-2 | 09 |
| STPB-SPARE-7-PLC1-DI-02 | SPARE | RIO2A | PLC-001 | DI-2 | 10 |
| STPB-SPARE-8-PLC1-DI-02 | SPARE | RIO2A | PLC-001 | DI-2 | 11 |
| STPB-SPARE-9-PLC1-DI-02 | SPARE | RIO2A | PLC-001 | DI-2 | 12 |
| STPB-STPB-YA-FIT-9302 | SLUDGE TRANSFER PUMP DISCHARGE FLOW FAIL ALARM | RIO2A | PLC-001 | DI-2 | 13 |
| STPB-STPB-PB_01FSH_01 | TRN A SLDG HOLD TANK AIR FLOW DEV ALARM | RIO2A | PLC-001 | DI-2 | 14 |
| STPB-STPB-STP_1_STP_I | SLDG XREF PUMP SELECT STP1/STP2 STATUS | RIO2A | PLC-001 | DI-2 | 15 |
| STPB-STPB-STP_1_PSH_I | SLDG XREF PUMP DISCH PRESS HIGH | RIO2A | PLC-001 | DI-2 | 16 |
| STPB-YS-LIT-9101 | TRAIN A SLUDGE BLEND TANK "BT-01" LEVEL | RIO2A | PLC-002 | AI-1 | 01 |
| STPB-YS-LI-9111 | SCUM PIT 1 LEVEL | RIO2A | PLC-002 | AI-1 | 02 |
| STPB-YS-LI-9121 | SCUM PIT 2 LEVEL | RIO2A | PLC-002 | AI-1 | 03 |
| STPB-YS-FIT-9201 | SLUDGE DISCHARGE HEADER FLOW PUMPS 1-3 | RIO2A | PLC-002 | AI-1 | 04 |
| STPB-SPARE-1-PLC2-AI-01 | SPARE | RIO2A | PLC-002 | AI-1 | 05 |
| STPB-SPARE-2-PLC2-AI-01 | SPARE | RIO2A | PLC-002 | AI-1 | 06 |
| STPB-SPARE-3-PLC2-AI-01 | SPARE | RIO2A | PLC-002 | AI-1 | 07 |
| STPB-SPARE-4-PLC2-AI-01 | SPARE | RIO2A | PLC-002 | AI-1 | 08 |
| STPB-REM-TSLP1 | THICKENED SLUDGE PUMP NO.1 "STPB-TSLP-1" REMOTE STATUS | RIO2A | PLC-002 | DI-1 | 01 |
| STPB-AUTO-TSLP1 | THICKENED SLUDGE PUMP NO.1 "STPB-TSLP-1" AUTO STATUS | RIO2A | PLC-002 | DI-1 | 02 |
| STPB-RUNNING-TSLP1 | THICKENED SLUDGE PUMP NO.1 "STPB-TSLP-1" RUNNING STATUS | RIO2A | PLC-002 | DI-1 | 03 |
| STPB-FO-CV1-TSLP1 | THICKENED SLUDGE PUMP NO.1 CHECK VALVE "CV1" FAIL TO OPEN | RIO2A | PLC-002 | DI-1 | 04 |
| STPB-YS-PSL-9211 | LOW SEAL WATER PRESSURE "STPB-PSL-9211" FOR THICKENED SLUDGE PUMP NO.1 "STPB-TSLP-1" | RIO2A | PLC-002 | DI-1 | 05 |
| STPB-SPARE-1-PLC2-DI-01 | SPARE | RIO2A | PLC-002 | DI-1 | 06 |
| STPB-SPARE-2-PLC2-DI-01 | SPARE | RIO2A | PLC-002 | DI-1 | 07 |
| STPB-SPARE-3-PLC2-DI-01 | SPARE | RIO2A | PLC-002 | DI-1 | 08 |
| STPB-SPARE-4-PLC2-DI-01 | SPARE | RIO2A | PLC-002 | DI-1 | 09 |
| STPB-SPARE-5-PLC2-DI-01 | SPARE | RIO2A | PLC-002 | DI-1 | 10 |
| STPB-SPARE-6-PLC2-DI-01 | SPARE | RIO2A | PLC-002 | DI-1 | 11 |
| STPB-SPARE-7-PLC2-DI-01 | SPARE | RIO2A | PLC-002 | DI-1 | 12 |
| STPB-SPARE-8-PLC2-DI-01 | SPARE | RIO2A | PLC-002 | DI-1 | 13 |
| STPB-SPARE-9-PLC2-DI-01 | SPARE | RIO2A | PLC-002 | DI-1 | 14 |
| STPB-SPARE-10-PLC2-DI-01 | SPARE | RIO2A | PLC-002 | DI-1 | 15 |
| STPB-YA-FIT-9201 | SLUDGE DISCHARGE HEADER FLOW PUMPS 1-3 FAIL ALARM | RIO2A | PLC-002 | DI-1 | 16 |
| STPB-REM-TSLP2 | THICKENED SLUDGE PUMP NO.2 "STPB-TSLP-2" REMOTE STATUS | RIO2A | PLC-002 | DI-2 | 01 |
| STPB-AUTO-TSLP2 | THICKENED SLUDGE PUMP NO.2 "STPB-TSLP-2" AUTO STATUS | RIO2A | PLC-002 | DI-2 | 02 |

SLUDGE TRANSFER PUMP BUILDING

| I/O IDENTIFIER | DESCRIPTION | PANEL | RACK | MODULE | PT. |
|--------------------------|--|-------|---------|--------|-----|
| STPB-RUNNING-TSLP2 | THICKENED SLUDGE PUMP NO.2 "STPB-TSLP-2" RUNNING STATUS | RIO2A | PLC-002 | DI-2 | 03 |
| STPB-FO-CV2-TSLP2 | THICKENED SLUDGE PUMP NO.2 CHECK VALVE "CV2" FAIL TO OPEN | RIO2A | PLC-002 | DI-2 | 04 |
| STPB-YS-PSL-9221 | LOW SEAL WATER PRESSURE "STPB-PSL-9221" FOR THICKENED SLUDGE PUMP NO.2 "STPB-TSLP-2" | RIO2A | PLC-002 | DI-2 | 05 |
| STPB-SPARE-1-PLC2-DI-02 | SPARE | RIO2A | PLC-002 | DI-2 | 06 |
| STPB-SPARE-2-PLC2-DI-02 | SPARE | RIO2A | PLC-002 | DI-2 | 07 |
| STPB-SPARE-3-PLC2-DI-02 | SPARE | RIO2A | PLC-002 | DI-2 | 08 |
| STPB-SPARE-4-PLC2-DI-02 | SPARE | RIO2A | PLC-002 | DI-2 | 09 |
| STPB-SPARE-5-PLC2-DI-02 | SPARE | RIO2A | PLC-002 | DI-2 | 10 |
| STPB-SPARE-6-PLC2-DI-02 | SPARE | RIO2A | PLC-002 | DI-2 | 11 |
| STPB-SPARE-7-PLC2-DI-02 | SPARE | RIO2A | PLC-002 | DI-2 | 12 |
| STPB-SPARE-8-PLC2-DI-02 | SPARE | RIO2A | PLC-002 | DI-2 | 13 |
| STPB-SPARE-9-PLC2-DI-02 | SPARE | RIO2A | PLC-002 | DI-2 | 14 |
| STPB-SPARE-10-PLC2-DI-02 | SPARE | RIO2A | PLC-002 | DI-2 | 15 |
| STPB-SPARE-11-PLC2-DI-02 | SPARE | RIO2A | PLC-002 | DI-2 | 16 |
| STPB-REM-TSLP3 | THICKENED SLUDGE PUMP NO.3 "STPB-TSLP-3" REMOTE STATUS | RIO2A | PLC-002 | DI-3 | 01 |
| STPB-AUTO-TSLP3 | THICKENED SLUDGE PUMP NO.3 "STPB-TSLP-3" AUTO STATUS | RIO2A | PLC-002 | DI-3 | 02 |
| STPB-RUNNING-TSLP3 | THICKENED SLUDGE PUMP NO.3 "STPB-TSLP-3" RUNNING STATUS | RIO2A | PLC-002 | DI-3 | 03 |
| STPB-FO-CV3-TSLP3 | THICKENED SLUDGE PUMP NO.3 CHECK VALVE "CV3" FAIL TO OPEN | RIO2A | PLC-002 | DI-3 | 04 |
| STPB-YS-PSL-9231 | LOW SEAL WATER PRESSURE "STPB-PSL-9231" FOR THICKENED SLUDGE PUMP NO.3 "STPB-TSLP-3" | RIO2A | PLC-002 | DI-3 | 05 |
| STPB-SPARE-1-PLC2-DI-03 | SPARE | RIO2A | PLC-002 | DI-3 | 06 |
| STPB-SPARE-2-PLC2-DI-03 | SPARE | RIO2A | PLC-002 | DI-3 | 07 |
| STPB-SPARE-3-PLC2-DI-03 | SPARE | RIO2A | PLC-002 | DI-3 | 08 |
| STPB-SPARE-4-PLC2-DI-03 | SPARE | RIO2A | PLC-002 | DI-3 | 09 |
| STPB-SPARE-5-PLC2-DI-03 | SPARE | RIO2A | PLC-002 | DI-3 | 10 |
| STPB-SPARE-6-PLC2-DI-03 | SPARE | RIO2A | PLC-002 | DI-3 | 11 |
| STPB-REM-STP1 | SLUDGE TRANSFER PUMP NO.1 "STPB-STP-1" REMOTE STATUS | RIO2A | PLC-002 | DI-3 | 12 |
| STPB-AUTO-STP1 | SLUDGE TRANSFER PUMP NO.1 "STPB-STP-1" AUTO STATUS | RIO2A | PLC-002 | DI-3 | 13 |
| STPB-RUNNING-STP1 | SLUDGE TRANSFER PUMP NO.1 "STPB-STP-1" RUNNING STATUS | RIO2A | PLC-002 | DI-3 | 14 |
| STPB-YS-PSL9311 | LOW SEAL WATER PRESSURE "STPB-PSL-9311" FOR SLUDGE TRANSFER PUMP NO.1 "STPB-STP-1" | RIO2A | PLC-002 | DI-3 | 15 |
| STPB-FO-CV-STP1 | SLUDGE TRANSFER PUMP NO.1 CHECK VALVE FAIL TO OPEN | RIO2A | PLC-002 | DI-3 | 16 |
| STPB-RUNNING-GT-DMC1 | GRAVITY THICKENER NO.1 "GT-DMC-1" RAKE RUNNING STATUS | RIO2A | PLC-002 | DI-4 | 01 |
| STPB-TS1-GT-DMC1 | GRAVITY THICKENER NO.1 "GT-DMC-1" RAKE HIGH TORQUE STATUS | RIO2A | PLC-002 | DI-4 | 02 |
| STPB-YA-GT-DMC1 | GRAVITY THICKENER NO.1 "GT-DMC-1" COMMON ALARM | RIO2A | PLC-002 | DI-4 | 03 |
| STPB-TS2-GT-DMC1 | GRAVITY THICKENER NO.1 "GT-DMC-1" HIGH-HIGH TORQUE STATUS | RIO2A | PLC-002 | DI-4 | 04 |
| STPB-SPARE-1-PLC2-DI-04 | SPARE | RIO2A | PLC-002 | DI-4 | 05 |
| STPB-SPARE-2-PLC2-DI-04 | SPARE | RIO2A | PLC-002 | DI-4 | 06 |

SLUDGE TRANSFER PUMP BUILDING

| I/O IDENTIFIER | DESCRIPTION | PANEL | RACK | MODULE | PT. |
|-------------------------|---|-------|---------|--------|-----|
| STPB-HS-TSCP1-LOCAL | SCUM SYSTEM NO.1 "GT-TSCP-1" SELECTOR LOCAL | RIO2A | PLC-002 | DI-4 | 07 |
| STPB-HS-TSCP1-MANUAL | SCUM SYSTEM NO.1 "GT-TSCP-1" SELECTOR MANUAL | RIO2A | PLC-002 | DI-4 | 08 |
| STPB-HS-TSCP1-AUTO | SCUM SYSTEM NO.1 "GT-TSCP-1" SELECTOR AUTO | RIO2A | PLC-002 | DI-4 | 09 |
| STPB-HS-TSCP1-OFF | SCUM SYSTEM NO.1 "GT-TSCP-1" SELECTOR OFF | RIO2A | PLC-002 | DI-4 | 10 |
| STPB-HS-TSCP1-RECIRC | SCUM SYSTEM NO.1 "GT-TSCP-1" SELECTOR RECIRCULATE VALVE | RIO2A | PLC-002 | DI-4 | 11 |
| STPB-HS-TSCP1-DISCH | SCUM SYSTEM NO.1 "GT-TSCP-1" SELECTOR DISCHARGE VALVE | RIO2A | PLC-002 | DI-4 | 12 |
| STPB-OPEN-TSCP1-VALVE | SCUM SYSTEM NO.1 "GT-TSCP-1" RECIRCULATE VALVE OPEN | RIO2A | PLC-002 | DI-4 | 13 |
| STPB-CLOSED-TSCP1-VALVE | SCUM SYSTEM NO.1 "GT-TSCP-1" RECIRCULATE VALVE CLOSED | RIO2A | PLC-002 | DI-4 | 14 |
| STPB-RUN-TSCP1 | SCUM SYSTEM NO.1 "GT-TSCP-1" RUN STATUS | RIO2A | PLC-002 | DI-4 | 15 |
| STPB-YA-TSCP1 | SCUM SYSTEM NO.1 "GT-TSCP-1" COMMON ALARM | RIO2A | PLC-002 | DI-4 | 16 |
| STPB-RUNNING-GT-DMC2 | GRAVITY THICKENER NO.2 "GT-DMC-2" RAKE RUNNING STATUS | RIO2A | PLC-002 | DI-5 | 01 |
| STPB-TS1-GT-DMC2 | GRAVITY THICKENER NO.2 "GT-DMC-2" RAKE HIGH TORQUE STATUS | RIO2A | PLC-002 | DI-5 | 02 |
| STPB-YA-GT-DMC2 | GRAVITY THICKENER NO.2 "GT-DMC-2" COMMON ALARM | RIO2A | PLC-002 | DI-5 | 03 |
| STPB-TS2-GT-DMC2 | GRAVITY THICKENER NO.2 "GT-DMC-2" HIGH-HIGH TORQUE STATUS | RIO2A | PLC-002 | DI-5 | 04 |
| STPB-SPARE-1-PLC2-DI-05 | SPARE | RIO2A | PLC-002 | DI-5 | 05 |
| STPB-SPARE-2-PLC2-DI-05 | SPARE | RIO2A | PLC-002 | DI-5 | 06 |
| STPB-HS-TSCP2-LOCAL | SCUM SYSTEM NO.2 "GT-TSCP-2" SELECTOR LOCAL | RIO2A | PLC-002 | DI-5 | 07 |
| STPB-HS-TSCP2-MANUAL | SCUM SYSTEM NO.2 "GT-TSCP-2" SELECTOR MANUAL | RIO2A | PLC-002 | DI-5 | 08 |
| STPB-HS-TSCP2-AUTO | SCUM SYSTEM NO.2 "GT-TSCP-2" SELECTOR AUTO | RIO2A | PLC-002 | DI-5 | 09 |
| STPB-HS-TSCP2-OFF | SCUM SYSTEM NO.2 "GT-TSCP-2" SELECTOR OFF | RIO2A | PLC-002 | DI-5 | 10 |
| STPB-HS-TSCP2-RECIRC | SCUM SYSTEM NO.2 "GT-TSCP-2" SELECTOR RECIRCULATE VALVE | RIO2A | PLC-002 | DI-5 | 11 |
| STPB-HS-TSCP2-DISCH | SCUM SYSTEM NO.2 "GT-TSCP-2" SELECTOR DISCHARGE VALVE | RIO2A | PLC-002 | DI-5 | 12 |
| STPB-OPEN-TSCP2-VALVE | SCUM SYSTEM NO.2 "GT-TSCP-2" RECIRCULATE VALVE OPEN | RIO2A | PLC-002 | DI-5 | 13 |
| STPB-CLOSED-TSCP2-VALVE | SCUM SYSTEM NO.2 "GT-TSCP-2" RECIRCULATE VALVE CLOSED | RIO2A | PLC-002 | DI-5 | 14 |
| STPB-RUN-TSCP2 | SCUM SYSTEM NO.2 "GT-TSCP-2" RUN STATUS | RIO2A | PLC-002 | DI-5 | 15 |
| STPB-YA-TSCP2 | SCUM SYSTEM NO.2 "GT-TSCP-2" COMMON ALARM | RIO2A | PLC-002 | DI-5 | 16 |
| STPB-ON/OFF-STP1 | SLUDGE TRANSFER PUMP NO.1 "STPB-STP-1" ON/OFF CONTROL | RIO2A | PLC-002 | DO-1 | 01 |
| STPB-ON/OFF-TSLP1 | THICKENED SLUDGE PUMP NO.1 "STPB-TSLP-1" ON/OFF CONTROL | RIO2A | PLC-002 | DO-1 | 02 |
| STPB-ON/OFF-TSLP2 | THICKENED SLUDGE PUMP NO.2 "STPB-TSLP-2" ON/OFF CONTROL | RIO2A | PLC-002 | DO-1 | 03 |
| STPB-ON/OFF-TSLP3 | THICKENED SLUDGE PUMP NO.3 "STPB-TSLP-3" ON/OFF CONTROL | RIO2A | PLC-002 | DO-1 | 04 |
| STPB-SPARE-1-PLC2-DO-01 | SPARE | RIO2A | PLC-002 | DO-1 | 05 |
| STPB-SPARE-2-PLC2-DO-01 | SPARE | RIO2A | PLC-002 | DO-1 | 06 |
| STPB-SPARE-3-PLC2-DO-01 | SPARE | RIO2A | PLC-002 | DO-1 | 07 |
| STPB-SPARE-4-PLC2-DO-01 | SPARE | RIO2A | PLC-002 | DO-1 | 08 |
| STPB-YS-LIT-9102 | TRAIN B SLUDGE BLEND TANK "BT-02" LEVEL | RIO2A | PLC-003 | AI-1 | 01 |
| STPB-YS-LI-9131 | SCUM PIT 3 LEVEL | RIO2A | PLC-003 | AI-1 | 02 |
| STPB-YS-LI-9141 | SCUM PIT 4 LEVEL | RIO2A | PLC-003 | AI-1 | 03 |

SLUDGE TRANSFER PUMP BUILDING

| I/O IDENTIFIER | DESCRIPTION | PANEL | RACK | MODULE | PT. |
|--------------------------|--|-------|---------|--------|-----|
| STPB-YS-FIT-9202 | SLUDGE DISCHARGE HEADER FLOW PUMPS 4-6 | RIO2A | PLC-003 | AI-1 | 04 |
| STPB-SPARE-1-PLC3-AI-01 | SPARE | RIO2A | PLC-003 | AI-1 | 05 |
| STPB-SPARE-2-PLC3-AI-01 | SPARE | RIO2A | PLC-003 | AI-1 | 06 |
| STPB-SPARE-3-PLC3-AI-01 | SPARE | RIO2A | PLC-003 | AI-1 | 07 |
| STPB-SPARE-4-PLC3-AI-01 | SPARE | RIO2A | PLC-003 | AI-1 | 08 |
| STPB-REM-TSLP4 | THICKENED SLUDGE PUMP NO.4 "STPB-TSLP-4" REMOTE STATUS | RIO2A | PLC-003 | DI-1 | 01 |
| STPB-AUTO-TSLP4 | THICKENED SLUDGE PUMP NO.4 "STPB-TSLP-4" AUTO STATUS | RIO2A | PLC-003 | DI-1 | 02 |
| STPB-RUNNING-TSLP4 | THICKENED SLUDGE PUMP NO.4 "STPB-TSLP-4" RUNNING STATUS | RIO2A | PLC-003 | DI-1 | 03 |
| STPB-FO-CV1-TSLP4 | THICKENED SLUDGE PUMP NO.4 CHECK VALVE "CV4" FAIL TO OPEN | RIO2A | PLC-003 | DI-1 | 04 |
| STPB-YS-PSL9241 | LOW SEAL WATER PRESSURE "STPB-PSL-9241" FOR THICKENED SLUDGE PUMP NO.4 "STPB-TSLP-4" | RIO2A | PLC-003 | DI-1 | 05 |
| STPB-SPARE-1-PLC3-DI-01 | SPARE | RIO2A | PLC-003 | DI-1 | 06 |
| STPB-SPARE-2-PLC3-DI-01 | SPARE | RIO2A | PLC-003 | DI-1 | 07 |
| STPB-SPARE-3-PLC3-DI-01 | SPARE | RIO2A | PLC-003 | DI-1 | 08 |
| STPB-SPARE-4-PLC3-DI-01 | SPARE | RIO2A | PLC-003 | DI-1 | 09 |
| STPB-SPARE-5-PLC3-DI-01 | SPARE | RIO2A | PLC-003 | DI-1 | 10 |
| STPB-SPARE-6-PLC3-DI-01 | SPARE | RIO2A | PLC-003 | DI-1 | 11 |
| STPB-SPARE-7-PLC3-DI-01 | SPARE | RIO2A | PLC-003 | DI-1 | 12 |
| STPB-SPARE-8-PLC3-DI-01 | SPARE | RIO2A | PLC-003 | DI-1 | 13 |
| STPB-SPARE-9-PLC3-DI-01 | SPARE | RIO2A | PLC-003 | DI-1 | 14 |
| STPB-SPARE-10-PLC3-DI-01 | SPARE | RIO2A | PLC-003 | DI-1 | 15 |
| STPB-YA-FIT-9202 | SLUDGE DISCHARGE HEADER FLOW PUMPS 4-6 FAIL ALARM | RIO2A | PLC-003 | DI-1 | 16 |
| STPB-REM-TSLP5 | THICKENED SLUDGE PUMP NO.5 "STPB-TSLP-5" REMOTE STATUS | RIO2A | PLC-003 | DI-2 | 01 |
| STPB-AUTO-TSLP5 | THICKENED SLUDGE PUMP NO.5 "STPB-TSLP-5" AUTO STATUS | RIO2A | PLC-003 | DI-2 | 02 |
| STPB-RUNNING-TSLP5 | THICKENED SLUDGE PUMP NO.5 "STPB-TSLP-5" RUNNING STATUS | RIO2A | PLC-003 | DI-2 | 03 |
| STPB-FO-CV1-TSLP5 | THICKENED SLUDGE PUMP NO.5 CHECK VALVE "CV5" FAIL TO OPEN | RIO2A | PLC-003 | DI-2 | 04 |
| STPB-YS-PSL-9251 | LOW SEAL WATER PRESSURE "STPB-PSL-9251" FOR THICKENED SLUDGE PUMP NO.5 "STPB-TSLP-5" | RIO2A | PLC-003 | DI-2 | 05 |
| STPB-SPARE-1-PLC3-DI-02 | SPARE | RIO2A | PLC-003 | DI-2 | 06 |
| STPB-SPARE-2-PLC3-DI-02 | SPARE | RIO2A | PLC-003 | DI-2 | 07 |
| STPB-SPARE-3-PLC3-DI-02 | SPARE | RIO2A | PLC-003 | DI-2 | 08 |
| STPB-SPARE-4-PLC3-DI-02 | SPARE | RIO2A | PLC-003 | DI-2 | 09 |
| STPB-SPARE-5-PLC3-DI-02 | SPARE | RIO2A | PLC-003 | DI-2 | 10 |
| STPB-SPARE-6-PLC3-DI-02 | SPARE | RIO2A | PLC-003 | DI-2 | 11 |
| STPB-SPARE-7-PLC3-DI-02 | SPARE | RIO2A | PLC-003 | DI-2 | 12 |
| STPB-SPARE-8-PLC3-DI-02 | SPARE | RIO2A | PLC-003 | DI-2 | 13 |
| STPB-SPARE-9-PLC3-DI-02 | SPARE | RIO2A | PLC-003 | DI-2 | 14 |
| STPB-SPARE-10-PLC3-DI-02 | SPARE | RIO2A | PLC-003 | DI-2 | 15 |
| STPB-SPARE-11-PLC3-DI-02 | SPARE | RIO2A | PLC-003 | DI-2 | 16 |

SLUDGE TRANSFER PUMP BUILDING

| I/O IDENTIFIER | DESCRIPTION | PANEL | RACK | MODULE | PT. |
|-------------------------|--|-------|---------|--------|-----|
| STPB-REM-TSLP6 | THICKENED SLUDGE PUMP NO.6 "STPB-TSLP-6" REMOTE STATUS | RIO2A | PLC-003 | DI-3 | 01 |
| STPB-AUTO-TSLP6 | THICKENED SLUDGE PUMP NO.6 "STPB-TSLP-6" AUTO STATUS | RIO2A | PLC-003 | DI-3 | 02 |
| STPB-RUNNING-TSLP6 | THICKENED SLUDGE PUMP NO.6 "STPB-TSLP-6" RUNNING STATUS | RIO2A | PLC-003 | DI-3 | 03 |
| STPB-FO-CV3-TSLP6 | THICKENED SLUDGE PUMP NO.6 CHECK VALVE "CV6" FAIL TO OPEN | RIO2A | PLC-003 | DI-3 | 04 |
| STPB-YS-PSL-9231 | LOW SEAL WATER PRESSURE "STPB-PSL-9261" FOR THICKENED SLUDGE PUMP NO.6 "STPB-TSLP-6" | RIO2A | PLC-003 | DI-3 | 05 |
| STPB-SPARE-1-PLC3-DI-03 | SPARE | RIO2A | PLC-003 | DI-3 | 06 |
| STPB-SPARE-2-PLC3-DI-03 | SPARE | RIO2A | PLC-003 | DI-3 | 07 |
| STPB-SPARE-3-PLC3-DI-03 | SPARE | RIO2A | PLC-003 | DI-3 | 08 |
| STPB-SPARE-4-PLC3-DI-03 | SPARE | RIO2A | PLC-003 | DI-3 | 09 |
| STPB-SPARE-5-PLC3-DI-03 | SPARE | RIO2A | PLC-003 | DI-3 | 10 |
| STPB-SPARE-6-PLC3-DI-03 | SPARE | RIO2A | PLC-003 | DI-3 | 11 |
| STPB-REM-STP2 | SLUDGE TRANSFER PUMP NO.2 "STPB-STP-2" REMOTE STATUS | RIO2A | PLC-003 | DI-3 | 12 |
| STPB-AUTO-STP2 | SLUDGE TRANSFER PUMP NO.2 "STPB-STP-2" AUTO STATUS | RIO2A | PLC-003 | DI-3 | 13 |
| STPB-RUNNING-STP2 | SLUDGE TRANSFER PUMP NO.2 "STPB-STP-2" RUNNING STATUS | RIO2A | PLC-003 | DI-3 | 14 |
| STPB-YS-PSL-9321 | LOW SEAL WATER PRESSURE "STPB-PSL-9321" FOR SLUDGE TRANSFER PUMP NO.2 "STPB-STP-2" | RIO2A | PLC-003 | DI-3 | 15 |
| STPB-FO-CV-STP2 | SLUDGE TRANSFER PUMP NO.2 CHECK VALVE FAIL TO OPEN | RIO2A | PLC-003 | DI-3 | 16 |
| STPB-RUNNING-GT-DMC3 | GRAVITY THICKENER NO.3 "GT-DMC-3" RAKE RUNNING STATUS | RIO2A | PLC-003 | DI-4 | 01 |
| STPB-TS1-GT-DMC3 | GRAVITY THICKENER NO.3 "GT-DMC-3" RAKE HIGH TORQUE STATUS | RIO2A | PLC-003 | DI-4 | 02 |
| STPB-YA-GT-DMC3 | GRAVITY THICKENER NO.3 "GT-DMC-3" COMMON ALARM | RIO2A | PLC-003 | DI-4 | 03 |
| STPB-TS2-GT-DMC3 | GRAVITY THICKENER NO.3 "GT-DMC-3" HIGH-HIGH TORQUE STATUS | RIO2A | PLC-003 | DI-4 | 04 |
| STPB-SPARE-1-PLC3-DI-04 | SPARE | RIO2A | PLC-003 | DI-4 | 05 |
| STPB-SPARE-2-PLC3-DI-04 | SPARE | RIO2A | PLC-003 | DI-4 | 06 |
| STPB-HS-TSCP3-LOCAL | SCUM SYSTEM NO.3 "GT-TSCP-3" SELECTOR LOCAL | RIO2A | PLC-003 | DI-4 | 07 |
| STPB-HS-TSCP3-MANUAL | SCUM SYSTEM NO.3 "GT-TSCP-3" SELECTOR MANUAL | RIO2A | PLC-003 | DI-4 | 08 |
| STPB-HS-TSCP3-AUTO | SCUM SYSTEM NO.3 "GT-TSCP-3" SELECTOR AUTO | RIO2A | PLC-003 | DI-4 | 09 |
| STPB-HS-TSCP3-OFF | SCUM SYSTEM NO.3 "GT-TSCP-3" SELECTOR OFF | RIO2A | PLC-003 | DI-4 | 10 |
| STPB-HS-TSCP3-RECIRC | SCUM SYSTEM NO.3 "GT-TSCP-3" SELECTOR RECIRCULATE VALVE | RIO2A | PLC-003 | DI-4 | 11 |
| STPB-HS-TSCP3-DISCH | SCUM SYSTEM NO.3 "GT-TSCP-3" SELECTOR DISCHARGE VALVE | RIO2A | PLC-003 | DI-4 | 12 |
| STPB-OPEN-TSCP3-VALVE | SCUM SYSTEM NO.3 "GT-TSCP-3" RECIRCULATE VALVE OPEN | RIO2A | PLC-003 | DI-4 | 13 |
| STPB-CLOSED-TSCP3-VALVE | SCUM SYSTEM NO.3 "GT-TSCP-3" RECIRCULATE VALVE CLOSED | RIO2A | PLC-003 | DI-4 | 14 |
| STPB-RUN-TSCP3 | SCUM SYSTEM NO.3 "GT-TSCP-3" RUN STATUS | RIO2A | PLC-003 | DI-4 | 15 |
| STPB-YA-TSCP3 | SCUM SYSTEM NO.3 "GT-TSCP-3" COMMON ALARM | RIO2A | PLC-003 | DI-4 | 16 |
| STPB-RUNNING-GT-DMC4 | GRAVITY THICKENER NO.4 "GT-DMC-4" RAKE RUNNING STATUS | RIO2A | PLC-003 | DI-5 | 01 |
| STPB-TS1-GT-DMC4 | GRAVITY THICKENER NO.4 "GT-DMC-4" RAKE HIGH TORQUE STATUS | RIO2A | PLC-003 | DI-5 | 02 |
| STPB-YA-GT-DMC4 | GRAVITY THICKENER NO.4 "GT-DMC-4" COMMON ALARM | RIO2A | PLC-003 | DI-5 | 03 |
| STPB-TS2-GT-DMC4 | GRAVITY THICKENER NO.4 "GT-DMC-4" HIGH-HIGH TORQUE STATUS | RIO2A | PLC-003 | DI-5 | 04 |

SLUDGE TRANSFER PUMP BUILDING

| I/O IDENTIFIER | DESCRIPTION | PANEL | RACK | MODULE | PT. |
|-------------------------|---|-------|---------|--------|-----|
| STPB-SPARE-1-PLC3-DI-05 | SPARE | RIO2A | PLC-003 | DI-5 | 05 |
| STPB-SPARE-2-PLC3-DI-05 | SPARE | RIO2A | PLC-003 | DI-5 | 06 |
| STPB-HS-TSCP4-LOCAL | SCUM SYSTEM NO.4 "GT-TSCP-4" SELECTOR LOCAL | RIO2A | PLC-003 | DI-5 | 07 |
| STPB-HS-TSCP4-MANUAL | SCUM SYSTEM NO.4 "GT-TSCP-4" SELECTOR MANUAL | RIO2A | PLC-003 | DI-5 | 08 |
| STPB-HS-TSCP4-AUTO | SCUM SYSTEM NO.4 "GT-TSCP-4" SELECTOR AUTO | RIO2A | PLC-003 | DI-5 | 09 |
| STPB-HS-TSCP4-OFF | SCUM SYSTEM NO.4 "GT-TSCP-4" SELECTOR OFF | RIO2A | PLC-003 | DI-5 | 10 |
| STPB-HS-TSCP4-RECIRC | SCUM SYSTEM NO.4 "GT-TSCP-4" SELECTOR RECIRCULATE VALVE | RIO2A | PLC-003 | DI-5 | 11 |
| STPB-HS-TSCP4-DISCH | SCUM SYSTEM NO.4 "GT-TSCP-4" SELECTOR DISCHARGE VALVE | RIO2A | PLC-003 | DI-5 | 12 |
| STPB-OPEN-TSCP4-VALVE | SCUM SYSTEM NO.4 "GT-TSCP-4" RECIRCULATE VALVE OPEN | RIO2A | PLC-003 | DI-5 | 13 |
| STPB-CLOSED-TSCP4-VALVE | SCUM SYSTEM NO.4 "GT-TSCP-4" RECIRCULATE VALVE CLOSED | RIO2A | PLC-003 | DI-5 | 14 |
| STPB-RUN-TSCP4 | SCUM SYSTEM NO.4 "GT-TSCP-4" RUN STATUS | RIO2A | PLC-003 | DI-5 | 15 |
| STPB-YA-TSCP4 | SCUM SYSTEM NO.4 "GT-TSCP-4" COMMON ALARM | RIO2A | PLC-003 | DI-5 | 16 |
| STPB-ON/OFF-STP2 | SLUDGE TRANSFER PUMP NO.2 "STPB-STP-2" ON/OFF CONTROL | RIO2A | PLC-003 | DO-1 | 01 |
| STPB-ON/OFF-TSLP4 | THICKENED SLUDGE PUMP NO.4 "STPB-TSLP-4" ON/OFF CONTROL | RIO2A | PLC-003 | DO-1 | 02 |
| STPB-ON/OFF-TSLP5 | THICKENED SLUDGE PUMP NO.5 "STPB-TSLP-5" ON/OFF CONTROL | RIO2A | PLC-003 | DO-1 | 03 |
| STPB-ON/OFF-TSLP6 | THICKENED SLUDGE PUMP NO.6 "STPB-TSLP-6" ON/OFF CONTROL | RIO2A | PLC-003 | DO-1 | 04 |
| STPB-SPARE-1-PLC3-DO-01 | SPARE | RIO2A | PLC-003 | DO-1 | 05 |
| STPB-SPARE-2-PLC3-DO-01 | SPARE | RIO2A | PLC-003 | DO-1 | 06 |
| STPB-SPARE-3-PLC3-DO-01 | SPARE | RIO2A | PLC-003 | DO-1 | 07 |
| STPB-SPARE-4-PLC3-DO-01 | SPARE | RIO2A | PLC-003 | DO-1 | 08 |

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